

**PRESENT LANDFILL AREA
GROUND-WATER/SURFACE WATER
COLLECTION STUDY
ROCKY FLATS PLANT SITE**

**Task 8
of the
Zero-Offsite Water-Discharge Study**

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EXECUTIVE SUMMARY

This report is of one of several studies being conducted for, and in the development of, a Zero-Offsite Water-Discharge Plan for the Rocky Flats Plant (RFP) in response to Item C.7 of the Agreement in Principle between the Colorado Department of Health (CDH) and the U.S. Department of Energy (DOE) (ASI, 1990a). The CDH/DOE Agreement Item C.7 states "Source Reduction and Zero Discharges Study: conduct a study of all available methods to eliminate Rocky Flats discharges to the environment including surface waters and groundwater. This review should include a source reduction review."

Specifically, this report addresses issues related to the surface and groundwater management at the Present Landfill at the RFP. This study presents a review of analytical data associated with the groundwater/leachate, and an analysis of the expected quantities of water to be managed. This study also assesses possible management alternatives for the contaminated groundwater/leachate that is generated at the landfill. The information in this report may prove useful in the determination and implementation of water management alternatives at the landfill.

The current configuration of the Present Landfill includes perimeter surface water control ditches around the landfill, a groundwater intercept system around the western portions of the landfill, a slurry wall cutoff system along the eastern portions of the landfill, a surface water control pond immediately downstream and downgradient of the landfill, and current waste disposal operations at the eastern end of the landfill. A number of monitoring wells have been installed in and around the landfill in order to investigate groundwater and leachate quality conditions in the area. If the current configuration of the landfill provided for runoff from the landfill, the runoff would be collected in the perimeter ditches and routed downstream of the landfill pond.

The issues related to water management at the Present Landfill include a number of sometimes conflicting issues. First, the Present Landfill has operated in the past, and is currently operating,

similar to a municipal landfill. However, the landfill is also considered a hazardous waste management landfill for the purposes of site investigation and remediation. This regulatory status is due to the inadvertent disposal of some materials in the landfill that may have qualified as listed hazardous wastes. This status of the landfill clouds some of the issues related to management of the waters related to the landfill.

A major issue at any landfill is the minimization and management of leachate. For the landfill itself, an inverse relationship exists between the quantity of leachate from the landfill and the quantity of runoff from the landfill. Maximizing the quantity of runoff at the landfill will reduce the quantity of leachate generated. Landfills are normally constructed in such a manner that the waste placed in the landfill creates a mound that provides for runoff of incident precipitation. The Present Landfill is not graded for optimal runoff at the current time. Future landfill configuration changes, particularly an appropriately graded cap, will serve to reduce leachate generation from the current levels. Collection and treatment of runoff from the completed landfill cap is not directly required by the regulations, but cannot be completely ruled out in the current regulatory situation.

A leachate seep exists at the east end of the landfill; it is believed that the majority of leachate exits the landfill at this point. The leachate seep flows directly into the pond east of the landfill. This pond currently operates as a zero-discharge pond. Collection and treatment of the leachate flow may be a required activity at the landfill in the near future. All data regarding this flow are limited, but available data have been analyzed. The leachate flow is currently estimated at an average of 3.2 gallons per minute (gpm), or approximately 1,700,000 gallons per year. Based on an assumption regarding infiltration of precipitation into the landfill, average leachate flows of up to 11 gpm, or approximately 5,766,000 gallons per year may be experienced. Capping of the landfill in accordance with Resource Conservation and Recovery Act regulations may reduce leachate flows to no more than 0.6 gpm (approximately 308,000 gallons per year).

One interpretation of the RCRA regulations is that the pond has received a listed hazardous waste (the landfill leachate). Therefore, the pond water itself could also be a listed hazardous waste. This interpretation has no dependency on actual water quality analyses. In this instance treatment of the pond water is necessary, and may include collection and treatment of water (whether leachate or runoff) that would enter the pond. Similarly, it can be argued that the runoff from the future graded and capped landfill requires collection and treatment. Current combined leachate (3.2 gpm) and runoff flow to the pond is estimated at 5,232,000 gallons per year. Maximum combined leachate (11 gpm) and runoff flow to the pond, as well as the combined leachate and runoff flow to the pond following final capping are both expected to be approximately 9,299,000 gallons per year. Evaporative losses from the pond in the course of a year are 2,056,000 gallons.

Landfill leachate appears more contaminated than groundwater in the area with respect to total dissolved solids, major ions, gross alpha and gross beta activity. The possibility of low levels (part per billion range) of volatile organic compound contamination of the leachate is also a possibility based upon wastes that were placed in the landfill, and based upon analyses of leachate in the landfill. The activity of tritium in the leachate has recently (since 1988) varied from 270 - 630 pCi/l; whereas, leachate contamination with tritium of 5,000 - 7,000 pCi/l had been noted in 1974.

Treatment alternatives for the leachate flow proposed as a result of this study include: sewage treatment plant (STP) treatment, mechanical evaporation, and reverse osmosis of the entire leachate flow followed by evaporation of the rejected brine. The actual treatment option selected will depend in part upon the results of other Zero-Offsite Water-Discharge Studies. The final treatment option selected will also depend on the results of the ongoing investigation, characterization and remediation activities for the landfill.

Relative costs of the three treatment options were estimated based upon the anticipated conceptual design of the facilities. Costs were calculated based solely upon those costs that would be unique for treatment of the leachate. The relative costs of the three treatment options were:

- 1) Mechanical evaporators are the least expensive in capital cost, but the most expensive in operations and maintenance costs.
- 2) The sewage treatment plant option is the second most costly in capital costs, but is considered to overall be the least expensive option. Operations and maintenance costs are minor.
- 3) Treatment of the leachate by reverse osmosis unit followed by evaporation of the rejected brine has the highest capital costs and moderate operations and maintenance costs.

A matrix was constructed to compare the treatment alternatives with management concerns to best evaluate the treatment alternatives. The preferred treatment options, in order from most desirable to least desirable, are: mechanical evaporation with a score of 330, reverse osmosis and mechanical evaporation with a score of 299, and STP treatment with a score of 246. The treatment option that includes treatment of the leachate in the STP may require hazardous waste delisting activities. These activities would involve delisting the STP effluent from the lists of hazardous wastes identified in the hazardous waste regulations. These delisting activities may be both time intensive and costly, and will need to be addressed in any re-evaluation of treatment options for the ITPH water. In particular, the matrix score for the STP treatment option is subject to re-evaluation based on the results of other Zero-Offsite Water Discharge Studies. If the STP effluent were to be completely recycled, the STP treatment alternative could very well become the preferred treatment alternative.

Recommendations include:

- Installation of a continuous flow measuring and recording device at the landfill seep;

- Appropriate grading and installation of an interim cover to minimize leachate generation at the end of operations;
- Continued groundwater and leachate monitoring in the landfill area; and
- Continued analysis of the landfill pond water.

Studies which are subordinate to the Zero-Offsite Water-Discharge Plan will rely on the results presented in this report. Particular studies which are influenced by this report are: the Sanitary Treatment Plant Evaluation (Task 10); Process Water Reuse (Task 11), Reverse Osmosis Mechanical Evaporator (Task 12); Treated Wastewater Recycle (Task 13); Water Rights (Task 14); Groundwater Cutoff/Diversion (Task 26); Waste Generation/Treatment (Task 27); and Augmentation Plan (Task 28). Specific relationships and influences among these tasks will be addressed in the Consolidation Plan as a result of the Zero-Offsite Water-Discharge Plan.

1.0 INTRODUCTION

This report is one component study of the Zero-Offsite Water-Discharge Study. This subordinate study is an analysis of existing data regarding the quantity and quality of leachate that is generated at the Rocky Flats Plant (RFP) Present Landfill. The RFP Present Landfill is also known as Operable Unit (OU) 7. An analysis of possible flow variations is also presented along with the potential sensitivity of the system to certain modifications. The Present Landfill is the subject of potential remedial actions, and therefore these data are needed for long-term management of leachate generated at the landfill. In addition to an analysis of the quantity and quality of leachate flow, a brief analysis of the net annual inflows to the landfill pond immediately east of the landfill is also presented. This analysis is presented because collection and treatment of the entire landfill pond contents may be a required activity during landfill remediation activities. A preliminary analysis of treatment systems for the leachate is also presented. This evaluation of treatment systems is preliminary and conceptual, and will not determine the leachate treatment system ultimately selected for use at the RFP Present Landfill. Section 5 of this report discusses the treatment options and provides additional details on ultimate selection of the chosen leachate treatment option.

The Present Landfill at the Rocky Flats Plant is undergoing an investigation, characterization and remediation process as described in the draft Interagency Agreement (IAG). The draft IAG is expected to be signed by the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Colorado Department of Health (CDH) in the near future. The process described in the IAG, along with the work presented in this study, ultimately will help guide the selection of the preferred remedial action at the present landfill. The potential for Interim Remedial Actions and Final Actions related to the landfill likely would involve a water-management program upgraded from the current water management program. The Present Landfill is currently contributing leachate flow to the pond immediately east of the landfill. This leachate is potentially contaminated with materials placed in the landfill and their decomposition products.

Knowledge of the expected volume and chemical characteristics of the leachate will allow the identification of an acceptable management program and the design of an appropriately sized treatment system.

An appropriate conceptual design of a treatment system currently is anticipated to include a pump station that collects leachate flows, a surge tank for containment of anticipated surge flows, and a treatment system sized to handle the existing average annual flows. The surge tank is a necessary unit due to the higher flows anticipated at certain times of the year.

2.0 HISTORY

2.1 CONSTRUCTION AND FILLING

The RFP Present Landfill is located to the north of the RFP manufacturing area, and was first used in 1968. Use of the landfill began after a study determined that a landfill operation would be the most efficient and economical means to dispose of the plant's nonradioactive solid wastes. Figure 1 identifies the location of the landfill, along with the various components of the landfill design.

Major changes in landfill operation and design took place during the fall of 1974 in response to the identification of a tritium source in the landfill (Rockwell International, 1988a). Design changes for the landfill consisted of the construction of two ponds immediately east of the landfill, a ground-water interceptor system for uncontaminated ground-water, a leachate-collection system and surface-water control ditches. The purpose of the west pond, Pond #1, was to provide a permanent structure to impound any leachate generated by the landfill. The purpose of the east pond, Pond #2, was to provide a permanent structure suitable for the collection of any contaminated ground-water flowing from the ground-water interceptor system. The leachate-collection system drained only to Pond #1. The ground-water interceptor system was provided with valves so that any collected ground-water could flow to Pond #1, Pond #2, or entirely bypass the ponds associated with the landfill.

Pond #1 was removed in 1981 because the landfill continued to expand into that area and there appeared to be no need for the pond. Two slurry walls were constructed in 1981 in order to allow for additional eastward expansion of the landfill. These slurry walls were connected to the eastern ends of the ground-water intercept system, and extended 700 feet (ft) eastward from this point.

The regulatory status of the Present Landfill changed in the fall of 1986 in response to the identification of the disposal of hazardous wastes in the landfill. At that time, the hazardous wastes being sent for disposal in the landfill were segregated out for separate disposal, and a Resource Conservation and Recovery Act (RCRA) Interim Status Closure Plan was submitted for the landfill. The intent of the Interim Status Closure Plan was to investigate conditions at the landfill and close the unit in a manner that prevented long-term threats to human health and the environment from the landfill. The Interim Status Closure Plan for the landfill was revised on July 1, 1990, in response to comments received on the Closure Plan from the EPA and the Colorado Department of Health (CDH). Due to ongoing negotiation of an Interagency Agreement (IAG), the Closure Plan for the landfill was superseded by a RCRA Facility Investigation/Remedial Investigation (RFI/RI) Work Plan in June 1990. The intent of the RFI/RI process outlined in the IAG is the same as the intent of a RCRA Closure Plan, but the procedures and steps followed are somewhat different.

2.2 EXISTING CONDITIONS

The conditions at the Present Landfill have been determined based upon surface water sampling, ground-water sampling and characterization of the general area based upon these programs. RCRA ground-water monitoring wells were first installed at the landfill area in the fall of 1986.

3.0 WATER QUANTITY

The water that may need to be treated at the Present Landfill will consist of either leachate flows or combined leachate and runoff flows. The most practical points for the collection of these flows is either the east end of the landfill, or the east end of the landfill pond, depending on whether or not runoff or the pond water is to be treated.

Therefore, this study evaluates:

- current leachate flows,
- maximum expected leachate flows,
- expected leachate flows following final capping of the landfill,
- current runoff to the landfill pond, and
- expected runoff to the landfill pond following final capping of the landfill.

The final cap for the landfill has not yet been designed, but it is anticipated to consist of a moderately sloped, multi-layer design similar to that presented in Figure 2. The final design will be determined in the course of the landfill investigation, characterization and remediation activities described in the IAG. The cap will increase the runoff of precipitation from the landfill, thereby decreasing the production of leachate from the landfill. However, collection and treatment of this runoff is a potential requirement.

3.1 MEASURED LEACHATE FLOW

The inflow to the landfill pond at the toe of the landfill is composed of a continuous leachate flow. This flow has been measured a number of times during the course of collection of water samples for analysis at surface water monitoring station SW-97. On August 29, 1990, the landfill leachate was quantified specifically for this project using an 8" Palmer Bowlus flume. The

measured flow was 6.7 gallons per minute. Table 1 is a presentation of the flow measurement dates and flows. The reported flows vary from 0 to 26.9 gallons per minute (gpm), with the majority of flows in the range of 1 - 4 gpm. The flows of April 6, 1989 (26.9 gpm) and October 9, 1989 (24.7 gpm) are believed to be in error. These flows are an order of magnitude greater than any of the other measured flows, and were followed about one month later by much smaller flow measurements. Large fluctuations in leachate flow are not normally experienced at landfills, and there are no unique characteristics at this landfill that would lead to these fluctuations. Therefore, the April 6, 1989 and October 9, 1989 flows will be ignored in data analyses. Based upon the flow measurements presented in Table 1, a reasonable estimate of overall annual flow of leachate out of the RFP landfill at the current time is approximately 3.2 gpm (1,700,000 gallons per year), which will be considered the current baseline flow of leachate out of the landfill. The maximum observed flow during the period of record is 6.7 gpm, ignoring the two other discussed flows. It is expected that the observed leachate flow at this location will increase with time based upon the analysis presented below.

TABLE 1
MEASURED LEACHATE FLOW*

<u>Date of Flow Measurement</u>	<u>Gallons Per Minute (gpm)</u>
6/16/88	2.2
4/06/89	26.9**
5/19/89	0.0
6/20/89	0.0
7/07/89	3.6
8/02/89	4.0
9/06/89	2.2
10/09/89	24.7**
11/07/89	1.8
12/05/89	1.8
8/29/90	6.7

* Flow measured at Surface Water Sampling Station SW-97.

** It is believed that these numbers are incorrect.

3.2 EXPECTED LEACHATE FLOW: CURRENT CONDITIONS

The area of the landfill within the ground-water interceptor system is approximately 813,600 square feet (ft²), or 18.7 acres. The design of the landfill is such that if the ground-water interceptor system and the slurry walls are operational, the only major input to leachate flow out of the landfill is incident precipitation. It is possible, however, that geologic media subcrop into the landfill deeper than the ground-water interceptor system and that water flowing in these media also contributes to leachate flow. However, it is impossible, at this time, to evaluate the quantity of water that may be contributed in this manner due to the need for a complete geologic re-characterization of the landfill. The data for this re-characterization is currently being generated. Although the re-characterization is not yet complete, it is felt that any such contribution to the total leachate flow will be relatively minor because of the relatively low hydraulic conductivities of most geologic media identified at the RFP.

Water balance calculations are an accepted and routine method used to try to estimate expected leachate flow from a landfill. Water balance calculations were conducted for the landfill based upon information presented in Lu, et al, 1984. These water balance calculations account for precipitation, evapotranspiration and soil water storage on a monthly basis. The result of these calculations indicated that the expected leachate production from this landfill is zero. The primary reason for this result is due to expected evapotranspiration in the Denver area exceeding expected precipitation (Hansen, Chronic and Matelock, 1978). Even though these water balance calculations indicate no expected leachate production on a regional basis, leachate production at Denver area landfills is known. Other methods to determine leachate production were therefore sought.

The average annual precipitation at the Rocky Flats Plant is approximately 15.16 inches (Rockwell International, 1989). The existing landfill cover is composed of soil and construction rubble placed over the landfilled waste. The soil and construction rubble is not sloped for

drainage. This configuration promotes infiltration of precipitation into the landfill. Due to this configuration, it is assumed that the coefficient of runoff from the landfill is approximately 0.25 (Lu, et al, 1984), leaving approximately 75% of total incident precipitation to infiltrate the landfill surface and contribute to leachate generation. This amount of precipitation and runoff would result in an annual contribution of approximately 5,766,000 gallons to leachate flow, with an average flow rate of approximately 11 gpm. This flow is more than three times the generally measured flow at the leachate seep. This difference between the measured flow and the predicted flow indicates that the landfill has probably not yet reached hydraulic equilibrium, and that leachate flows will slowly increase with time unless a more effective cap is placed on the landfill.

A qualitative evaluation of expected variations in leachate flow can be completed by determining the time-of-flow from the farthest west point of the landfill to the pond. If this time-of-flow is relatively short, then greater fluctuations of the leachate flow due to precipitation events would be expected. However, if the time-of-flow is relatively long, then the leachate flow would be less reflective of any given precipitation event or period. A time of flow analysis was conducted using data presented in the "1989 Annual RCRA Ground-Water Monitoring Report for Regulated Units at the Rocky Flats Plant," (EG&G, 1990). This data included a maximum hydraulic conductivity of the landfilled materials of approximately 6.7×10^{-4} centimeters per second (cm/sec), and an average annual hydraulic gradient of 0.0423 feet per foot in the landfill. This hydraulic gradient is from the west end of the landfill to the landfill pond surface. The effective porosity of the landfill materials was assumed to be 0.1. Based on these data the travel time of groundwater from the west end of the landfill to the east end of the landfill is approximately 1,940 days, or approximately 5.3 years. Time of flow for groundwater from the approximate middle (west to east, in the vicinity of wells 6387 and 6487) of the landfill to the pond is approximately 2.6 years. These times-of-flow are relatively long, and they indicate that fluctuations in leachate flow to any specific precipitation event should be relatively minor.

More sophisticated methods of prediction of leachate flows exist, but most of these methods require more data than is currently available for the RFP Present Landfill. The application of some of these other methods of prediction should be re-considered in the future as data becomes available.

3.3 PREDICTED LEACHATE FLOW: EXPECTED FUTURE CONDITIONS

Landfills are normally capped with a clayey, low permeability soil and graded to promote runoff of precipitation. Additionally, hazardous waste landfills are normally required to include an impermeable flexible membrane liner as a portion of its capping system. A cap designed in this manner would provide for runoff with a minimum of precipitation infiltrating the landfill cover. Based on a conservative assumption of 4% of total annual precipitation infiltrating the cover, and the implementation of other actions to prevent clean groundwater entering the landfill, the annual generation of leachate would be on the order of approximately 308,000 gallons, or an average annual flow of 0.6 gpm. It is possible that the cap will allow less than 4% infiltration, decreasing leachate flow even more. However, 0.6 gpm could be considered the long-term flow from the landfill that a leachate collection system may need to treat. Based on the time-of-flow calculations, it may require on the order of 5.3 years for the leachate flow out of the landfill to reach hydraulic equilibrium with the new cap. Until that time, leachate flows exiting the landfill will be decreasing, but they will still exceed the minimum flow predicted.

3.4 POND WATER BALANCE

At the current time runoff from the entire landfill is not routed to the landfill pond, but collection and treatment of this runoff is a possible requirement. The following analyses are presented based on changed conditions in which runoff from the landfill is routed to the landfill pond.

3.4.1 Existing Conditions

The land area that could be tributary to the pond is approximately 1,210,000 ft² (including the landfill itself). This is the area that is within the surface water diversion ditches which surround the landfill. Of this total area, approximately 813,600 ft² is the landfill with a runoff coefficient of approximately 0.25 (Lu, et al, 1984). The remainder of the area is composed of the slightly sloped, low permeability Rocky Flats alluvium. These non-landfill areas are assumed to have a runoff coefficient of approximately 0.43. This runoff coefficient is similar to that of an undeveloped areas with an undefined land use (DRCOG, 1969). Based on annual precipitation and this runoff coefficient, the current amount of runoff that could be contributed to the landfill pond is approximately 3,532,000 gallons per year. In addition to this runoff, the pond also collects approximately 1,700,000 gallons per year of leachate flow into the west end of the pond (based on an inflow of 3.2 gpm as discussed in Section 3.2 of this report). Therefore, known and expected inputs to the pond account for approximately 5,232,000 gallons per year. An additional unquantified inflow of groundwater is also being added to the pond.

The surface area of the pond is approximately 108,000 ft². Appendix A provides an analysis of the amount of net evaporation in the Denver area based upon annual precipitation rates and pan evaporation rates. The net evaporation from the pond (total small reservoir evaporation minus precipitation) is approximately 30.6 inches per year, or 1.6 gallons per square foot of reservoir area per month. Therefore, total evaporative losses from the landfill pond are approximately 2,056,000 gallons per year.

The above analysis result in a current net annual contribution to the landfill pond of approximately 3,176,000 gallons. This number represents the annual quantity of water that would need to be treated if the entire landfill pond flow was treated. The pond water balance is given in Figure 3.

The pond water balance should also be recalculated based on the maximum anticipated leachate flow into the pond. This flow is 11 gpm, resulting in a net annual contribution to the landfill pond of approximately 7,242,000 gallons.

3.4.2 Expected Future Conditions

The expected final configuration of the landfill will be a graded cover provided with a capping system that meets the RCRA requirements for a hazardous waste landfill. This configuration will provide for total runoff from the landfill of approximately 96%. This change could increase total runoff to the pond to approximately 8,991,000 gallons per year, all other factors remaining the same. However, the landfill will eventually reach hydraulic equilibrium with the new cap, which is expected to result in reduced leachate flows of approximately 308,000 gallons per year (0.6 gpm). These total inputs of approximately 9,298,000 gallons per year are reduced by the net evaporation of water from the pond of approximately 2,056,000 gallons per year. Therefore, the difference of 7,243,000 gallons per year represents the long-term annual quantity of water that would need to be treated if the entire landfill pond flow was treated following final capping of the Present Landfill.

3.5 SUMMARY AND RECOMMENDATIONS

Table 2 is a summary table of flow quantities at the RFP Present Landfill. This table includes flows measured or expected at the current time, as well as flows expected in the future due to changing conditions at the landfill.

TABLE 2
SUMMARY OF FLOW QUANTITIES

<u>Flow</u>	<u>Existing Conditions</u> <u>(gpm)</u>	<u>Expected Future Conditions</u> <u>(gpm)</u>
Leachate Flow	3.2* - 11**	0.6
Leachate & Runoff Into Pond	6* - 14**	14

*Arithmetic average of measured leachate flows.

**Based on estimate of infiltration of precipitation.

Measured flows of the leachate seep into the landfill pond have varied considerably, but most measured flows have been in the 1 - 4 gpm range. The current estimate of annual leachate flow is 3.2 gpm. If the landfill were at hydraulic equilibrium, the expected leachate flow is on the order of 11 gpm. Therefore, the landfill may not be at hydraulic equilibrium. Leachate flows from the landfill seep are expected to decrease following final capping of the landfill until flows on the order of 0.6 gpm are experienced.

The following recommendations will allow for increased accuracy of flow quantification in the future:

- a permanent measuring station should be installed to continuously measure leachate flow into the landfill pond,
- any observed changes in leachate flow in response to storm events or other changes should be recorded,
- the sooner an adequate landfill cover is placed on the RFP landfill, the smaller the total quantities of leachate requiring treatment will be,
- estimates of runoff quantities specific to either the landfill area or specific to the RFP area should be conducted in order to better verify runoff coefficients of the RFP materials, and

- additional water balance calculations should be conducted for the landfill as data to support more elaborate studies becomes available.

In general, smaller flow quantities must be treated if treatment occurs at the point of leachate seepage (toe of the landfill). Further, a major contributor of flow to the landfill pond could be runoff from the landfill and surrounding land. The combined leachate and pond water may potentially be more difficult to treat due to its more dilute nature.

4.0 WATER QUALITY

Water quality has been analyzed from surface water monitoring stations and groundwater monitoring wells in the vicinity of the landfill. These data are of interest to this report in order to determine appropriate leachate treatment alternatives, and in order to try to determine whether significant variations in leachate quality can be anticipated. It should be noted that available data were used in this evaluation. EG&G Rocky Flats has an extensive QA/QC program to determine the quality of the data and the suitable uses of data based upon the objective of that use. Therefore, this evaluation and discussion may be revised in the future depending upon both the results of new analyses and the results of the QA/QC program.

4.1 MONITORING STATIONS

Currently, there are 4 areas where surface water is monitored in the vicinity of the landfill. The sampling stations are shown below:

<u>Station</u>	<u>Description</u>
SW-97	Landfill Seep (leachate flow)
SW-98	Landfill Pond
SW-99	North Groundwater (GW) Intercept Discharge
SW-100	South GW Intercept Discharge

These stations have been sampled intermittently between June, 1988 and March, 1990. No flow measurements were available for SW-99 or SW-100. The averages for each parameter that was detected are given in Table 3. A topographic map of the stations is given in Figure 4.

TABLE 3
SURFACE WATER MONITORING DATA

Constituent	Landfill Seep	Landfill Pond	North GW Intercept Discharge	South GW Intercept Discharge	UNITS
	SW097	SW098	SW099	SW100	
Barium	0.7	ND	0.2	0.32	mg/l
Copper	0.011	ND	ND	0.024	mg/l
Iron	62	3.5	1.4	25	mg/l
Lithium	0.012	ND		0.02	mg/l
Manganese	1.8	0.34	0.014	0.78	mg/l
Mercury	ND	ND	ND	ND	mg/l
Nickel	ND	<0.01	ND	0.01	mg/l
Selenium	ND	ND	ND	0.13	mg/l
Silver	ND	ND	ND	ND	mg/l
Strontium	0.95	0.48	0.58	2.01	mg/l
Zinc	3.47	0.99	0.09	0.2	mg/l
Calcium	176	69	98	321	mg/l
Magnesium	40	40.7	27.3	63.7	mg/l
Potassium	6.8	11.4	0.16	24.8	mg/l
Sodium	94	157	60	194	mg/l
Bicarbonate	668	471	341	96	mg/l
Chloride	83	140	29	30	mg/l
Sulfate	5.3	35	46	150	mg/l
TDS	979	756	481	904*	mg/l
Gross Alpha	12.2	2.47	37.9	69.5	pCi/l
Gross Beta	24	11.6	26.3	110	pCi/l
Plutonium-239	0.47	0.048	0.03	0.017	pCi/l
Uranium, Total	2.65	2.75	6.11	16.5	pCi/l
Tritium	607.5	168	55	331	pCi/l
Radium-226	3.5	MISSING	1.4	11	pCi/l

* By Addition of Ions

4.2 PROPOSED CONCENTRATION LIMITS

Proposed concentration limits are presented in Table 4. These proposed concentration limits represent background concentrations in Rocky Flats groundwater, except for Safe Drinking Water Act (SDWA) metals. These proposed concentration limits are used as a point of reference for comparison with water quality analyses near the landfill.

TABLE 4: PROPOSED CONCENTRATION LIMITS FOR ROCKY FLATS ALLUVIUM

	<u>Constituent</u>	<u>Concentration</u>
<u>Metals</u>	++Ag	0
	Al	5.0
	++As	0.05
	++Ba	1
	+Be	0
	Ca	NS
	++Cd	0.01
	+Co	0
	++Cr	0.05
	Cs	0
	+Cu	0
	Fe	0.3
	++Hg	0.002
	K	NS
	+Li	0
	Mg	NS
	Mn	0.36
	Mo	0.1
	Na	NS
	+Ni	0.04
	++Pb	0.05
	+Sb	0
	++Se	0.01
	Sr	0.16
	+Tl	0
	+V	0
	+Zn	0.14
<u>Other Inorganics (mg/l):</u>	HCO ₃	NS
	Cl	250
	SO ₄	250
	NO ₃	10
	TDS	400
<u>Dissolved Radionuclides (pCi/l):</u>	Gross Alpha	11
	Gross Beta	19
	Pu 239, 240	0.05
	Am 241	0.05
	Total Uranium	5
	Sr 89,90	8
	Cs 137	NS
	H3	500

Source: 1989 Annual RCRA Groundwater Monitoring Report

4.3 LEACHATE

Landfill leachate is normally a highly concentrated liquid with elevated levels of organic and inorganic contaminants. Treatment of leachate is often difficult due to its concentrated nature. For samples collected from June 1988 through March 1990, the RFP landfill seepage (leachate) exceeded the proposed standard as shown below in Table 5 indicating some type of leachate treatment may be necessary.

TABLE 5
COMPARISON OF LEACHATE QUALITY TO THE PROPOSED STANDARD

<u>Constituent</u>	<u>Exceeded Standard/Number of Times Sampled</u>
Total Dissolved Solids	4/4
Iron	13/13
Manganese	13/13
Zinc	13/13
Strontium	11/13
Gross Alpha	2/5
Gross Beta	3/5
Tritium	2/5
Total Uranium	2/5
Plutonium	2/7
Lithium	1/13

Source: RFP database

The leachate contributes solvents, polynuclear aromatic hydrocarbons (PNA's) as well as oil and grease. The seepage exceeds background concentration for other constituents including bicarbonate, calcium, magnesium, and sodium.

However, as Table 6 illustrates, the actual concentrations of contaminants identified in the RFP landfill leachate are relatively dilute. Similarly, a comparison of the RFP landfill leachate with

leachate from other landfills (Table 7) indicates that RFP landfill leachate is typically near the minimum concentration of detected pollutants in municipal landfill leachate. This leachate is therefore somewhat atypical of landfill leachates. Acceptable treatment schemes for the RFP landfill leachate may therefore include options that are not normally associated with more concentrated landfill wastes.

Comparison of the landfill leachate with sample analyses from wells actually sampling water in the Landfill (Wells 63-87 and 64-87) does not indicate that major changes in leachate characteristics are expected. Concentrations of contaminants are similar among these various sampling points, indicating that leachate characteristics should remain similar with time.

Using the average values for the constituents and the measured flow rate, the seepage is contributing approximately 1.7 pounds of solvents, 0.13 pounds of PNA's and 32 pounds of oil and grease to the landfill pond per year. In addition, the leachate is contributing approximately 7 tons of salts to the pond per year or roughly 4 tons of salts above background level.

4.4 LANDFILL POND

The landfill pond routinely exceeds the RFP standard for strontium. The pond has also exceeded the standard for copper, iron, lithium, manganese, mercury, nickel, plutonium and zinc. The landfill pond also contains uranium, gross alpha and gross beta close to the proposed standard. The landfill pond contains approximately twice the TDS and three times the strontium of the proposed standard.

4.5 GROUNDWATER INTERCEPT SYSTEM

The groundwater intercept system is able to discharge to the surface via SW 99 for the North intercept system and SW 100 for the South intercept system.

TABLE 6: AVERAGE VALUES FOR LANDFILL SEEPAGE (June 1988 - March 1990)

<u>Compound</u>	<u>Detected/Sampled</u>	<u>Average Concentration</u>	<u>Sample Range</u>	<u>Units</u>
Barium	13/13	0.70	0.608-1.06	mg/l
Calcium	13/13	176	149-189	mg/l
Copper	4/13	0.011	ND - 0.045	mg/l
Iron	13/13	62	41.2-84.3	mg/l
Lithium	2/13	0.012	ND-0.080	mg/l
Magnesium	13/13	40	34.1-46.8	mg/l
Manganese	13/13	1.8	1.6-2.11	mg/l
Mercury	1/13	<0.0001	0-0.0003	mg/l
Nickel	0/13	ND	---	mg/l
Potassium	12/12	6.8	5.27-8.12	mg/l
Selenium	0/13	ND	---	mg/l
Silver	1/13	<0.01	ND-0.0131	mg/l
Sodium	13/13	94	84-115	mg/l
Strontium	11/13	0.95	ND-1.21	mg/l
Zinc	13/13	3.47	0.802-6.05	mg/l
Bicarbonate	4/4	893	731-1000	mg/l
Chloride	4/4	83	49.6-100	mg/l
Sulfate	3/4	5.3	ND-1.3	mg/l
TDS	4/4	979	727-1200	mg/l
Gross Alpha Radiation	3/4	12.2 ± 16.8	0-40	Pci/l
Gross Beta Radiation	5/5	24.0 ± 8.5	5.7-35	Pci/l
Plutonium-239	7/7	0.063	ND-0.16	Pci/l
Uranium, Total	5/5	2.65	0.6-5.5	Pci/l
Tritium	4/4	607.5	270-1280	Pci/l
Radium-226	3/3	2.83	0.9-6.6	Pci/l
4-Methyl 2-Pentanone	6/10	6.2	ND-22	ug/l
1,1-Dichloroethene	5/10	4.9	ND-20	ug/l
2-Butanone	3/10	9.8	ND-76	ug/l
Acetone	2/6	10.5	ND-37	ug/l
Chloroethane	5/10	7.0	ND-20	ug/l
Ethyl Benzene	9/10	7.8	ND-12	ug/l
Methylene Chloride	5/6	6.2	ND-15	ug/l
Toluene	10/10	21.7	2-44	ug/l
Xylenes	8/10	6.3	ND-21	ug/l
TCE	4/10	1.5	ND-12	ug/l
1-2 Dichloroethene	2/9	1.2	ND-7	ug/l
4-Methyl Phenol	1/2	16.5	4-29	ug/l
Di-n-Butyl Phthlate	1/2	0.05	ND-0.1	ug/l
Di-Ethyl Phthlate	1/2	2	ND-4	ug/l
Fluorene	2/2	1	1	ug/l
Naphthalene	2/2	8	6-10	ug/l
Oil & Grease	1/4	2,250	ND-9.000	ug/l
Phenol	1/2	1	ND-2	ug/l

ND = Not detected

Source, RFP Database

4.5.1 South Intercept Groundwater

The South intercept groundwater shows signs of degraded quality, potentially from mixing with waste located outside the intercept system. The South Intercept water is the highest of the 4 surface water stations for: calcium (321 mg/l), copper (.024 mg/l), lithium (0.02 mg/l), magnesium (63.7 mg/l), potassium (24.8 mg/l), selenium (0.13 mg/l), strontium (2.01 mg/l), sulfate (150 mg/l), gross alpha and gross beta particle radiation (69.5 and 110 pCi/l respectfully), total uranium (16.5 Pci/l) and radium 226 (11 Pci/l). These values exceed groundwater sampled in or around landfill. Additional testing should be performed to determine the source of contamination for this groundwater. The TDS averages 904 mg/l over the course of the study period which is more than twice the proposed standard. Strontium levels are an order of magnitude greater than the proposed standard.

4.5.2 North Intercept Groundwater

The North intercept system is of considerably better quality than the South Intercept, closely matching the background levels for most dissolved metals in Rocky Flats Alluvium (EG&G, 1989). However, the proposed standard is exceeded for strontium and TDS on occasion. The North intercept groundwater is appreciably higher on the average for gross alpha and beta particle radiation, and total uranium.

4.6 GROUNDWATER QUALITY

According to the 1989 Groundwater Monitoring Report, the alluvial groundwater at the landfill appears to have elevated concentrations of 1,1,1-TCA, TCE, barium, calcium, iron, magnesium, manganese, sodium, strontium, zinc, sulfate, chloride, TDS, tritium and uranium. The present landfill may be impacting groundwater quality though increased major ion, copper, iron, manganese, strontium, uranium and zinc concentrations. Volatile organic compounds including

1,1,1 TCA, TCE, methylene chloride, toluene and chloroform have also been detected in the landfill.

Based on the number and concentrations of the inorganic parameters exceeding background, groundwater at wells 63-87 on the north side of the landfill and 70-87 on the southeast side of the landfill are the most elevated above background. Iron and manganese concentrations at well 63-87 are an order of magnitude above the proposed concentration standard. At both wells, TDS, strontium and uranium exceeded proposed concentration limits.

Although some minor impacts to groundwater quality are noted near the landfill, the groundwater quality characteristics from well to well are not significantly different. Significant increases in concentrations of contaminants are not even noted for those wells (63-87 and 64-87) that sample water (leachate) from within the landfill. These data include that significant changes in leachate quality are not expected since highly elevated contaminant concentrations have not been identified in the landfill area.

Table 7 compares the RFP landfill leachate to minimum and maximum values found in the literature for municipal landfill leachate and to the RFP background water quality.

TABLE 7
COMPARISON OF RFP LANDFILL LEACHATE TO OTHER MUNICIPAL LANDFILLS

<u>Constituent</u>	<u>Minimum*</u>	<u>Maximum*</u>	<u>Landfill Leachate**</u>	<u>RFP Background</u>
ALUMINUM (mg/l)	ND	122		ND
ANTIMONY (mg/l)	ND	47		ND
ARSENIC (mg/l)	ND	70.2		ND
BARIUM (mg/l)	ND	12.5	0.7	ND
BERYLLIUM (mg/l)	ND	0.36		ND
CADMIUM (mg/l)	ND	3900		ND
CALCIUM (mg/l)	5	7200	176	85
CESIUM (mg/l)				ND
CHROMIUM (mg/l)	ND	33.4		ND
COBALT (mg/l)	0.04	0.13		ND
COPPER (mg/l)	ND	10	0.011	ND
IRON (mg/l)	ND	5500	62	0.266
LEAD (mg/l)	ND	14.2		ND
LITHIUM (mg/l)			0.012	ND
MAGNESIUM (mg/l)	3	15600	40	5.79
MANGANESE (mg/l)	ND	1400	1.8	0.365
MERCURY (mg/l)	ND	0.2	<0.0001	ND
MOLYBDENUM (mg/l)	ND	1.43		0.0136
NICKEL (mg/l)	ND	79	ND	0.0423
POTASSIUM (mg/l)	ND	3800	6.8	7.73
SELENIUM (mg/l)	ND	1.85	ND	ND
SILVER (mg/l)	ND	1.96	<0.01	ND
SODIUM (mg/l)	ND	7700	94	13.4
STRONTIUM (mg/l)			0.95	0.159
THALLIUM (mg/l)	ND	0.86		ND
TIN (mg/l)	ND	2		ND
VANADIUM (mg/l)	ND	1.4		ND
ZINC (mg/l)	ND	1000	3.47	0.141
TDS (mg/l)	ND	51000	979	352
CARBONATE (mg/l)				ND
BICARBONATE (mg/l)	3260	5730	668	436
CHLORIDE (mg/l)	2	11375	83	15.6
SULFATE (mg/l)	ND	1850	5.3	45.1
NITRATE (mg/l)	ND	250		2.98
CYANIDE (mg/l)	ND	6		0.0038
pH (Standard Units)	3.7	12.5		8.6

TABLE 7 (continued)

<u>Constituent</u>	<u>Minimum*</u>	<u>Maximum*</u>	<u>Leachate**</u>
4-Methyl 2-Pentanone (ug/l)	10	710	6.2
1,1-Dichloroethylene (ug/l)	0.5	110	4.9
2-Dichloroethene (ug/l)			9.8
Acetone (ug/l)	8	13000	10.5
Chloroethane (ug/l)	<10	860	7
Ethyl Benzene (ug/l)	6	4900	7.8
Methylene Chloride (ug/l)	2	220000	6.2
Toluene (ug/l)	5.55	18000	21.7
Xylenes (ug/l)	12	310	21.7
Trichloroethylene (ug/l)	1	1300	1.5
Trans 1-2 Dichloroethene (ug/l)	2	4800	1.2
4-Methyl Phenol (p-cresol) (ug/l)	45.2	5100	16.5
Di-n-Butyl Phthlate (ug/l)	<10	150	0.05
Di-Ethyl Phthate (ug/l)	3	330	2
Fluorene (ug/l)			1
Napthalene (ug/l)	2	202	8
Oil & Grease (ug/l)			2250
Phenol (ug/l)	7.3	28800	1

* Minimum and maximum based on literature regarding other municipal landfills.

** Rocky Flats Plant Landfill leachate.

Sources:

Formation, Characteristics, Treatment and Disposal of Leachate from Municipal Solid Waste Landfills, Paul M. McGinley and Peter Kmet Wisconsin Department of Natural Resources, August 1, 1984.

Volatile Organic Compounds as Indicators of Municipal Solid Waste Leachate Contamination, Waste Management & Research (1984) 2119-130

Critical Review and Summary of Leachate and Gas Production from Landfills, PB86-240181, Prepared by Georgia Institute of Technology for the USEPA, Cincinnati, Ohio.

Monitoring of Leachate Migration in the Unsaturated Zone in the Vicinity of Sanitary Landfills, Thomas M. Johnson and Keros Cartwright, State Geological Survey Division, Urbana Illinois, 1980.

Solid Wastes and Engineering Principles and Management Issues, Tchobanoglous et. all, McGraw-Hill, INC., New York, 1977.

Summary of Data on Municipal Solid Waste Landfill Leachate Characteristics, "Criteria for Municipal Solid Waste Landfills" (40CFR258), USEPA Washington, DC, July 1988.

5.0 WATER MANAGEMENT ALTERNATIVES

This section of the report evaluates three water treatment alternatives for leachate flow at the landfill. These evaluations are based upon the technical merits of treating the water in one manner as opposed to another. Regulatory issues will influence the selection of the final leachate management alternative. Leachate management alternatives for the landfill water will be determined by the investigation, characterization and remediation process described in the draft IAG. These alternatives may consist of both interim remedial actions and final remedial actions. Completion of the IAG process will determine regulatory and technical issues that will impact future management of the landfill leachate. The no action alternative does not appear as a feasible alternative for long-term management of the leachate flows due to the requirements of the IAG process, and due to other regulatory concerns associated with the landfill. However, the no action alternative may be acceptable for the runoff in the area.

Treatment of leachate is the only issue discussed in this section of the report because the relatively dilute nature of the leachate would be diluted to an even greater extent by mixing of the leachate flow with runoff flows in the landfill pond. Treatment of combined leachate flows and landfill pond water does not appear to be required based upon the anticipated characteristics of the combined flows. Should treatment of these combined flows be required, some treatment units could be far more costly due to the increased hydraulic capacity that would be required.

As discussed in previous sections of this report, the leachate flow has the following characteristics:

- Current average annual flow of approximately 3.2 gpm.
- Expected maximum average annual flow of approximately 11 gpm.
- Fluctuations in leachate flow should be relatively minor.
- Fluctuations in leachate quality are expected to be minor.

- Quality of flow is characterized by increased concentrations of:
 - TDS
 - nitrate
 - VOCs
 - total dissolved solids

A treatment capacity of approximately 11 gpm with storage capacity of approximately 100,000 gallons will be adequate for treatment of any anticipated landfill leachate flows. The 100,000 gallon storage capacity is to provide flexibility and storage capacity at those times when the treatment system has operational problems or when treatment upsets occur. Modifications of the existing landfill system may influence the total required treatment capacity as well as the total required storage capacity.

Treatment alternatives for the landfill leachate proposed as a result of this study include: treatment of the leachate flow at the Sanitary Treatment Plant (STP); treatment of the leachate flow in the Building 374 evaporators; and treatment of the leachate flow by reverse osmosis followed by mechanical evaporation of the rejected brine in Building 374. The actual treatment option selected will depend, in part, upon the results of other Zero Discharge Study tasks.

The final treatment option selected will also depend on the results of the ongoing landfill investigation, characterization and remediation activities that are described in the draft IAG. It should be noted that the regulatory status of the landfill leachate is a consideration in selection of the appropriate treatment options for the waste. The regulatory status of the waste and the ramifications of treatment for any one of the options may make selection of that treatment option a regulatory impossibility. The treatment options discussed in this report are all considered to be technically feasible treatment alternatives at this time. Any long-term treatment option

pursued by the RFP for the landfill leachate should be discussed and receive approval from CDH and EPA prior to the implementation of that treatment option.

A matrix was used to compare and identify the most desirable treatment option. The matrix considers eleven factors, each of which is assigned a weighting factor of one to ten. The weighting factor reflects the perceived importance of the factor in final selection of a treatment alternative. A weighting factor of one implies a less important consideration and a weighting factor of ten implies a very important consideration. These weighting factors were selected by a committee of cognizant DOE and EG&G personnel. Each treatment option was assigned a score from one to five for each factor. The scores of each treatment option reflect the relative desirability of the treatment option. A score of one is least desirable and a score of five is most desirable. The treatment option with the highest overall score is the desired treatment option.

5.1 TREATMENT BY SEWAGE TREATMENT PLANT

One method for treating the leachate flow from the landfill is to pipe the leachate to the STP for treatment. This treatment option would require a pump station and force main to move the water from the landfill to the pre-aeration headworks of the RFP STP (Building 910). This will require approximately 3,100 feet of pipe. A storage tank would also be constructed at the landfill to allow flexibility for operational problems of the system.

Treatment of landfill leachate flows by an STP is relatively common (McGinley, 1984 and Lu et al, 1984). As discussed in Section 4 of this report, the RFP leachate quality tends to be near the minimum with respect to the concentrations of contaminants found in leachates from municipal solid waste landfills. This leachate can be effectively treated in the RFP STP.

An advantage of this alternative would be that no "new" treatment costs would be incurred, existing facilities and personnel would be used to provide for treatment of the landfill leachate.

The maximum average leachate flow expected of 15,800 GPD is insignificant compared to the STP average daily flow of approximately 190,000 GPD. The total anticipated costs (capital plus operation and maintenance) for this treatment alternative are presented in Table 8, and the summary evaluation matrix for all alternatives is presented in Table 9. The capital cost breakdown for this alternative is:

Pump Station to 910 Area	\$39,000
Force Main to 910 Area	50,100
Storage Tank	<u>208,100</u>
TOTAL	297,200

TABLE 8
ESTIMATED TREATMENT ALTERNATIVE COSTS

<u>ALTERNATIVE</u>		<u>CAPITAL COST</u> <u>(1990 \$)</u>	<u>O&M* COST</u> <u>(\$/year)</u>	<u>MATRIX</u> <u>RANK</u>
1)	Sewage Treatment Plant Treatment of all Flow	297,200	Negligible	3
2)	Mechanical Evaporation of all Flow	289,100	1,447,000	1
3)	Reverse Osmosis and Mechanical Evaporation of all Flow	582,000	507,000	2

*O&M = Operation and Maintenance

TABLE 9

EVALUATION MATRIX TASK 8

EVALUATION FACTORS	WEIGHTING FACTOR	ALT 1		ALT 2		ALT 3	
		S	W	S	W	S	W
CONTROLLED DISCHARGE	10	1	10	5	50	5	50
WASTE GENERATION	7	5	35	5	35	2	14
RISKS	8	4	32	5	40	3	24
COST	6	5	30	2	12	2	12
DESIGN AND CONSTRUCTION SCHEDULE	6	5	30	2	12	2	12
FLEXIBILITY	8	2	16	2	16	4	32
WATER RIGHTS	5	3	15	3	15	3	15
AIR EMISSIONS	10	2	20	5	50	5	50
WETLANDS/T&E SPECIES	10	3	30	3	30	3	30
IHSS (SWMU)	10	2	20	3	30	2	20
PUBLIC ACCEPTABILITY	8	1	8	5	40	5	40
TOTALS			246		330		299
RANK			3		1		2

S = SCORE; W = WEIGHTED SCORE = SCORE x WEIGHTING FACTOR

This is the least preferred treatment option of those studied due to the requirement for possible controlled discharge of an effluent, the possibility of air emissions from this treatment alternative, and due to the low public acceptability of this option. The overall score for this option is 246. On the other hand, this treatment alternative has a high score in waste generation because it does not generate a new waste, is the least costly treatment alternative, and could probably be implemented within the next year. This treatment alternative could become the preferred treatment alternative if the STP effluent were recycled at the RFP.

The feasibility of treatment through the STP will be further defined after completion of Task 10, Sewage Treatment Plant Evaluation. Task 10 will be of particular importance in re-evaluating the relative rankings of these treatment options if complete recycling of STP effluent is recommended. Complete recycling of the effluent would probably modify the scores for controlled discharge, air emissions, and public acceptability. However, given the regulatory status of the leachate, if the leachate is treated through the STP, it may be necessary to delist the effluent from the STP. This delisting specifically concerns the lists of hazardous waste identified in the RCRA regulations. These delisting activities may be both time intensive and costly, and will need to be addressed in any re-evaluation of treatment options for the leachate. The treatment and release of treated leachate from the STP may also require modification of the Rocky Flats Plant National Pollutant Discharge Elimination System (NPDES) Permit which is undergoing renewal.

5.2 Treatment By Existing Mechanical Evaporator

Another feasible treatment option is to pipe the leachate to Building 374 for treatment by the mechanical evaporator or a comparable unit. Implementation of this treatment option requires a pump station, force main and a storage tank at the landfill. Again, the purpose of the storage tank is to allow the treatment system operational flexibility in response to system upsets.

This alternative would not incur any "new" treatment costs. However, approximately 2,600 feet of pipe would be required. The addition of the leachate flow to the mechanical evaporator may be unacceptable as the mechanical evaporator is currently running at or near capacity. The operation of the Building 374 evaporators, including the generation of salt crete, should not be significantly impacted by the addition of this relatively dilute waste as an additional feed source. The total anticipated costs (capital plus operation and maintenance) for this treatment alternative are presented in Table 8, and the summary evaluation matrix for all alternatives is presented in Table 9. The capital cost breakdown for this alternative is:

Pump Station to 374 Area	\$39,000
Force Main to 374 Area	42,000
Storage Tank	<u>208,100</u>
TOTAL	289,100

This treatment option is the most preferred option with an overall score of 330. The reason for the high score for this treatment option is due to the total management of the leachate flow with relatively small waste generation. This treatment option has low probabilities for off-site discharges of air or water. Similarly, the risks for this treatment option are low due to it having the shortest pipeline. Public acceptability of this option is high due to the lack of off-site discharges of any sort.

The Mechanical Evaporator is currently being studied by ASI under Task 12 of the Zero Offsite Discharge Study.

5.3 Treatment by Reverse Osmosis

The leachate could also be treated via a portable treatment unit. One of the more suitable treatment units for this option is a reverse osmosis unit that could be constructed at the landfill. The characteristics of the leachate flow makes it suitable for reverse osmosis treatment, along

with evaporative treatment of the rejected brine at the Building 374 evaporator units. Implementation of this treatment option would require a reverse osmosis unit for the leachate, a building to house the reverse osmosis unit, a storage tank, and a pump station and force main to Building 374 for treatment of the rejected brine. The total anticipated costs (capital plus operation and maintenance) for this treatment alternative are presented in Table 8, and the summary evaluation matrix for all alternatives is presented in Table 9. The capital cost breakdown for this alternative is:

Reverse Osmosis Unit	\$316,800
Building	12,500
Pump Station to 374 Area	21,300
Force Main to 374 Area	23,300
Storage Tank	<u>208,100</u>
 TOTAL	 \$582,000

This treatment option is the second most preferred alternative with an overall score of 299. This alternative scores high for controlled discharge, air emissions, and public acceptability for reasons similar to the mechanical evaporator treatment alternative. However, this alternative scores relatively low for waste generation and design and construction schedule. These low scores are due to the generation of a new waste at the landfill that requires additional management, and due to the need for Building 374 to evaporate this waste. The need for Building 374 to treat the rejected brine waste may also cause delays in construction of this option, resulting in a relatively low score for this evaluation factor.

EVALUATION FACTORS - DEFINITIONS

COST:	1 = High Construction, O, M, & R Cost 5 = Low Construction, O, M, & R Cost
FLEXIBILITY:	1 = Small Ability to Respond to Changing Conditions 5 = Large Ability to Respond to Changing Conditions
RISK:	1 = High Risk 5 = Low Risk
PUBLIC ACCEPTABILITY:	1 = Low Likelihood of Public Acceptability 5 = High Likelihood of Public Acceptability
WATER RIGHTS:	1 = High Water Rights Impact 5 = Low Water Rights Impact
DESIGN AND CONST. SCHEDULE:	1 = Total Schedule Greater Than 5 Years 5 = Total Schedule 1 Year or Less
IHSS (SWMU):	1 = IHSS Are Impacted 5 = No IHSS Are Impacted
WETLANDS/T&E:	1 = Wetlands/T&E Species Are Impacted 5 = No Wetlands/T&E Species Are Impacted
WASTE GENERATION:	1 = Large Quantity of Solid Waste 5 = Small Quantity of Solid Waste
AIR EMISSIONS:	1 = High Air Emissions 5 = Low Air Emissions
CONTROLLED DISCHARGE:	1 = High Potential for Controlled Downstream Discharge 5 = Low Potential for Controlled Downstream Discharge

Note: Score on a scale of 5 (best) through 1 (worst)

MANAGEMENT ALTERNATIVES

CONTROLLED DISCHARGE:

Each alternative was considered for the quantity of water to be discharged. Alternative 1 will require some discharge after treatment at the STP and consequently received a low score. Alternatives 2 and 3, which will reuse/recycle treated water, received a high score.

WASTE GENERATION:

Solid waste generated from the treatment systems include salts and sludges. The STP treatment system and Building 374 already generate solid wastes. Alternatives 1 and 2 will only increase that quantity slightly. Alternative 3, in which the reverse osmosis reject will be sent to Building 374, is given a lower score due to the greater waste handling necessary in this option.

RISKS:

Risk was considered based on the volume of liquid stored and transported to the appropriate treatment facility. Alternative 3 would necessitate the liquid be treated at the landfill, with the reject pumped to a separate treatment facility. This is considered to be of higher risk than the other alternatives would require. Alternative 2 is regarded as being the least risky because piping and liquid transfer is minimized.

COSTS:

Relative costs of the treatment alternatives were estimated based upon the anticipated conceptual design of the treatment facilities. Alternative 1 presents the greatest cost advantage because the STP system exists and is capable of accepting the volume of liquid produced by the landfill.

Operations and maintenance costs will also be low for leachate treatment at the STP. This alternative will require a pump station, a storage tank, and a force main. Other alternatives will require these same components and additional equipment.

DESIGN AND CONSTRUCTION

SCHEDULE: Option 1, since it is independent of any other activities, may be able to be built within one year. Therefore it has a high score. Neither of alternatives 2 or 3 presents a clear advantage over the other in design and construction schedule. Alternative 2 may require modification of the Building 374 evaporators which could delay this project. Alternative 3, since it involves construction of new facilities, may also have a delayed construction schedule.

FLEXIBILITY: The flexibility of the alternatives is about equal with the exception of Alternative 3. The construction of a new treatment system will increase RFP plant flexibility. Use of the STP or 374 Evaporators will decrease RFP plant flexibility. However, alternative 3 does require brine treatment at 374, so the score is not maximized.

WATER RIGHTS: None of the alternatives represents any greater or lesser impact on water rights.

AIR EMISSIONS: Alternatives 2 and 3 are contained units and prevent the release of any air emissions and are given the highest scores. Alternative 1 does not have a process specific to the treatment of volatile organic

compounds and will probably result in some release to the atmosphere or of effluent.

WETLANDS/T&E SPECIES: None of the alternatives represents any greater or lesser impact on wetlands or threatened and endangered species.

IHSS (SWMU): The implementation of Alternative 2 will have the least degree of impact on IHSSs relative to the other options because it has the shortest pipeline. Because of longer pipelines required by Alternative 1, and the need for a pipeline and treatment system in alternative 3, these two alternatives scored slightly lower.

PUBLIC ACCEPTABILITY: Public health concerns are dependant on the release of products off the RFP. This release may occur in the atmosphere or in water discharges. The scoring of this category is the same as for Air Emissions.

6.0 ACKNOWLEDGEMENTS

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- R.A. Applehans, EG&G - FE/PSCE
- D. Fink, EG&G - ISP
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- S. McGlochlin, EG&G - NEPA
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- N. Fryback, EG&G - RCRA/ER
- C. Rose, CWAD Consultant

This report was prepared and submitted in partial fulfillment of the Zero-Offsite Water-Discharge Study being conducted by ASI on behalf of EG&G Rocky Flats, Inc.. EG&G's project engineer for this study was Mr. R.A. Applehans of EG&G's Facilities Engineering, Plant Civil-Structural Engineering (FE/PCSE) division.

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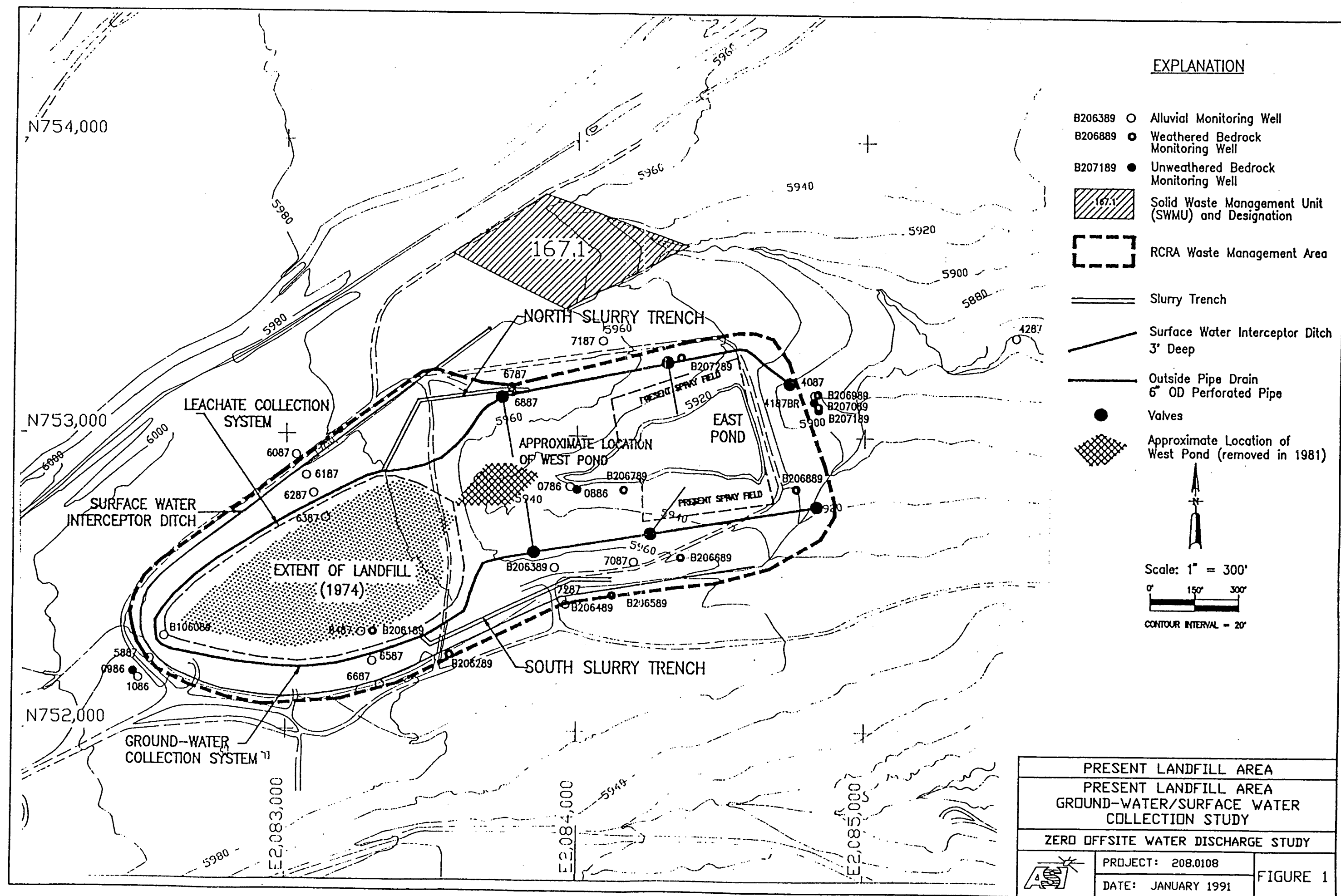
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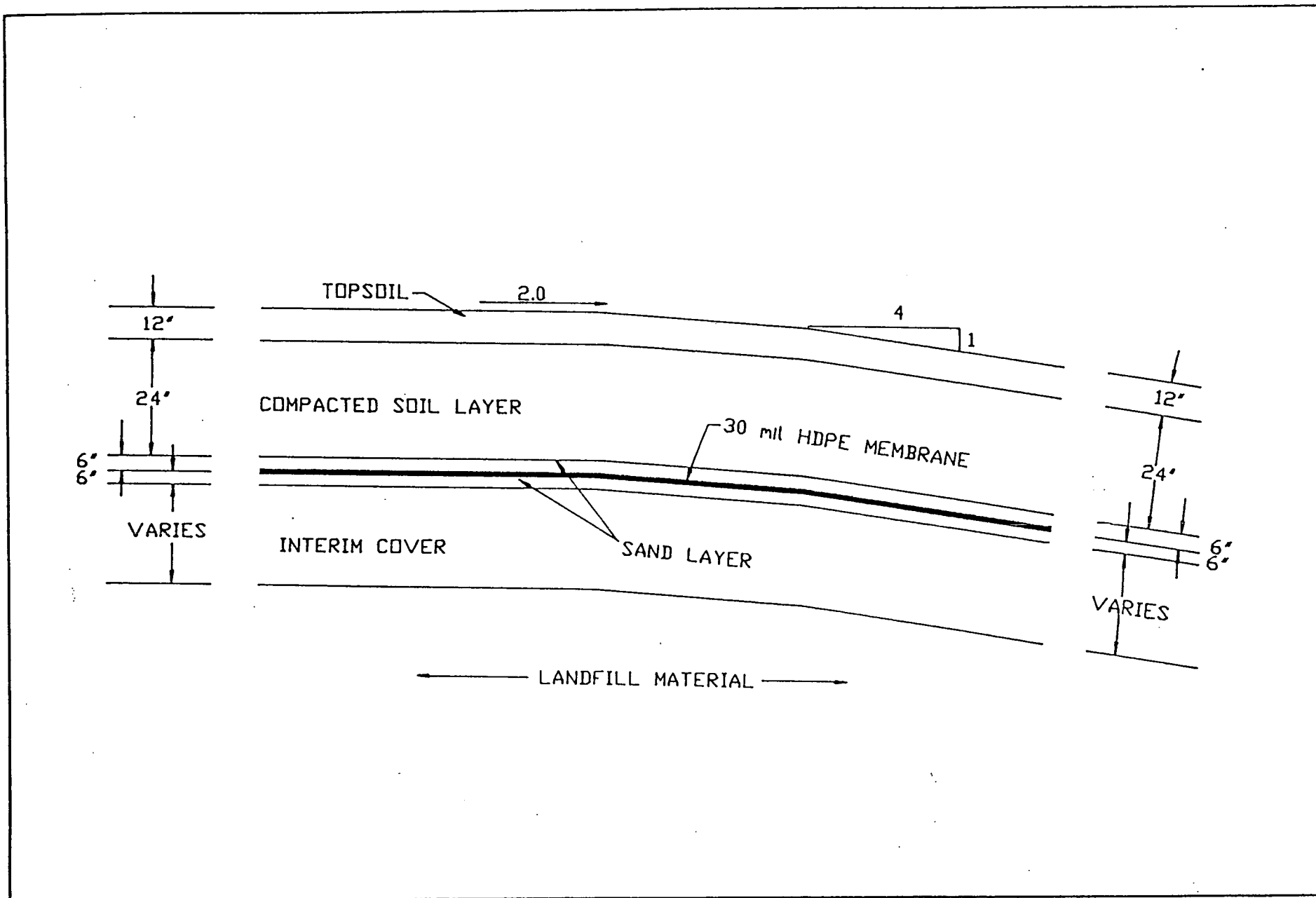
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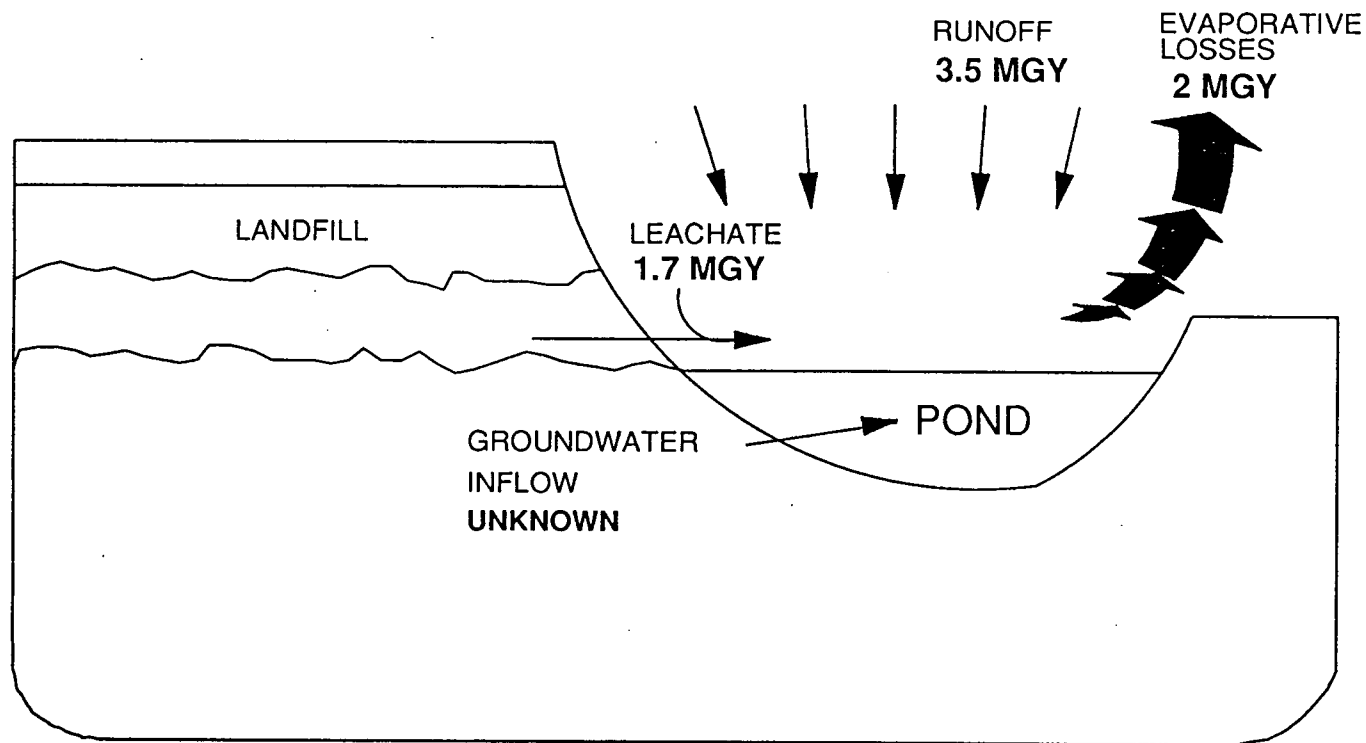
ANTICIPATED LANDFILL FINAL COVER

Present Landfill Area
Ground-Water/Surface Water Collection Study
Zero-Offsite Water Discharge

PROJECT 20801.08

FIGURE 2





NET ACCUMULATION = 3.2 MGY + GROUNDWATER INFLOW

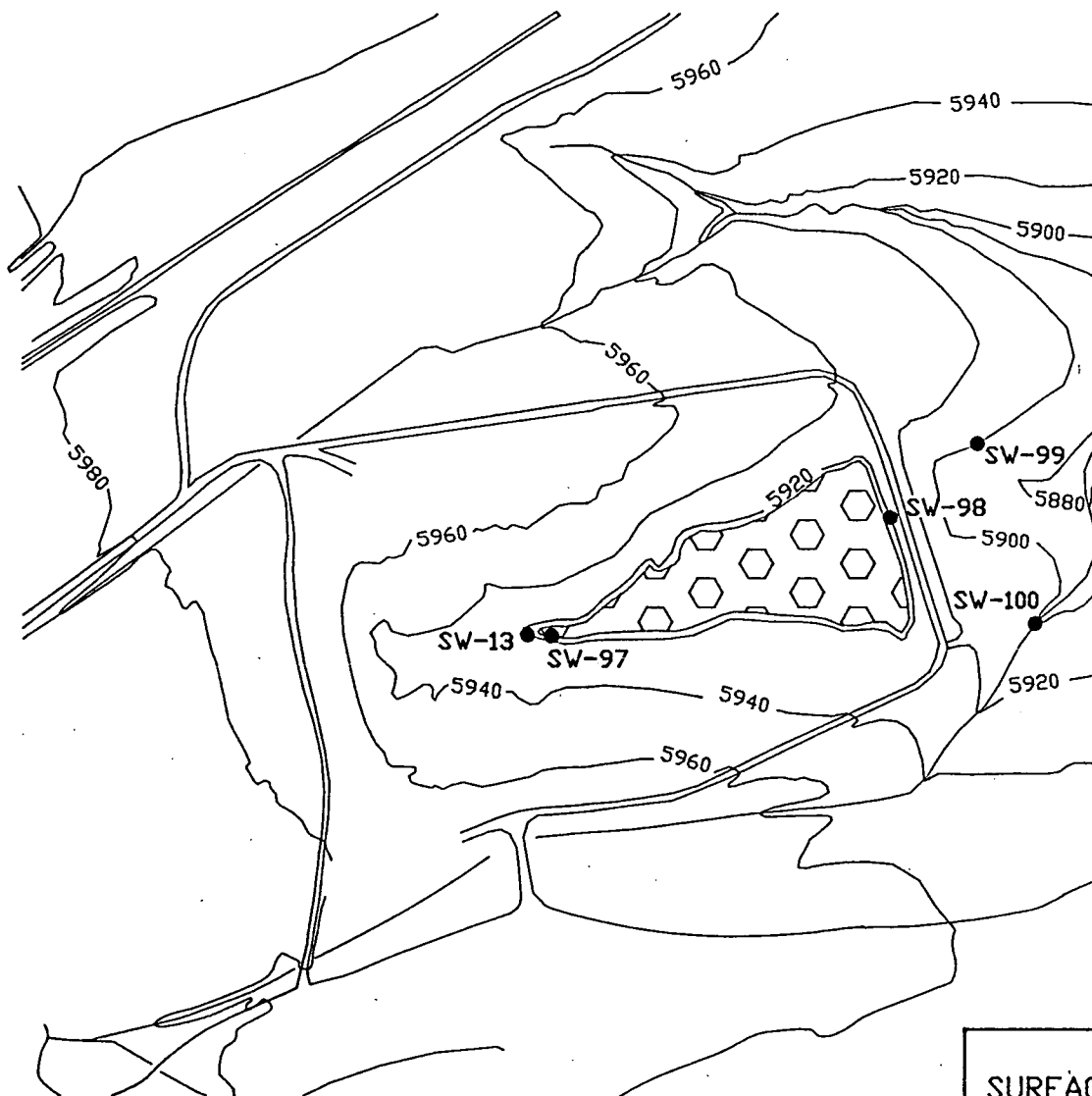
LANDFILL POND WATER BALANCE

Present Landfill Area
Ground-Water/Surface Water Collection Study
Zero-Offsite Water Discharge

PROJECT 20801.08

FIGURE 3





PRESENT LANDFILL AREA
SURFACE WATER MONITORING STATIONS

PRESENT LANDFILL AREA
GROUND-WATER/SURFACE WATER
COLLECTION STUDY

ZERO OFFSITE WATER DISCHARGE STUDY



PROJECT: 208.0108

DATE: JANUARY 1991

FIGURE 4

A

APPENDIX A
ANNUAL EVAPORATIVE LOSSES

APPENDIX A

ANNUAL EVAPORATIVE LOSSES

Average Annual Precipitation for Rocky Flats Plant, 15.16" (based on 24-year precipitation record). Source: Rocky Flats Plant Site Environmental Report for 1988, January - December, 1988, RFP-ENV-88, May 1989.

Average Annual Evaporation for Denver Area: 45.75" (70% of Class A Pan Evaporation). Source: Hazardous Waste Land Treatment Manual, SW-874, USEPA, Municipal Environmental Research Laboratory, Office of Research and Development, Cincinnati, Ohio, April 1983.

Average Net Annual Moisture Loss: 30.59"

Therefore, net evaporation losses per area are approximately: 1.6 gallons/ft²/month

Landfill pond area is approximately 108,000 ft². Therefore, evaporative losses from the pond are approximately 2,056,000 gallons per year.

<u>MONTH</u>	<u>APPROXIMATE PAN EVAPORATION IN DENVER</u> <u>PAN EVAPORATION (cm)*</u>
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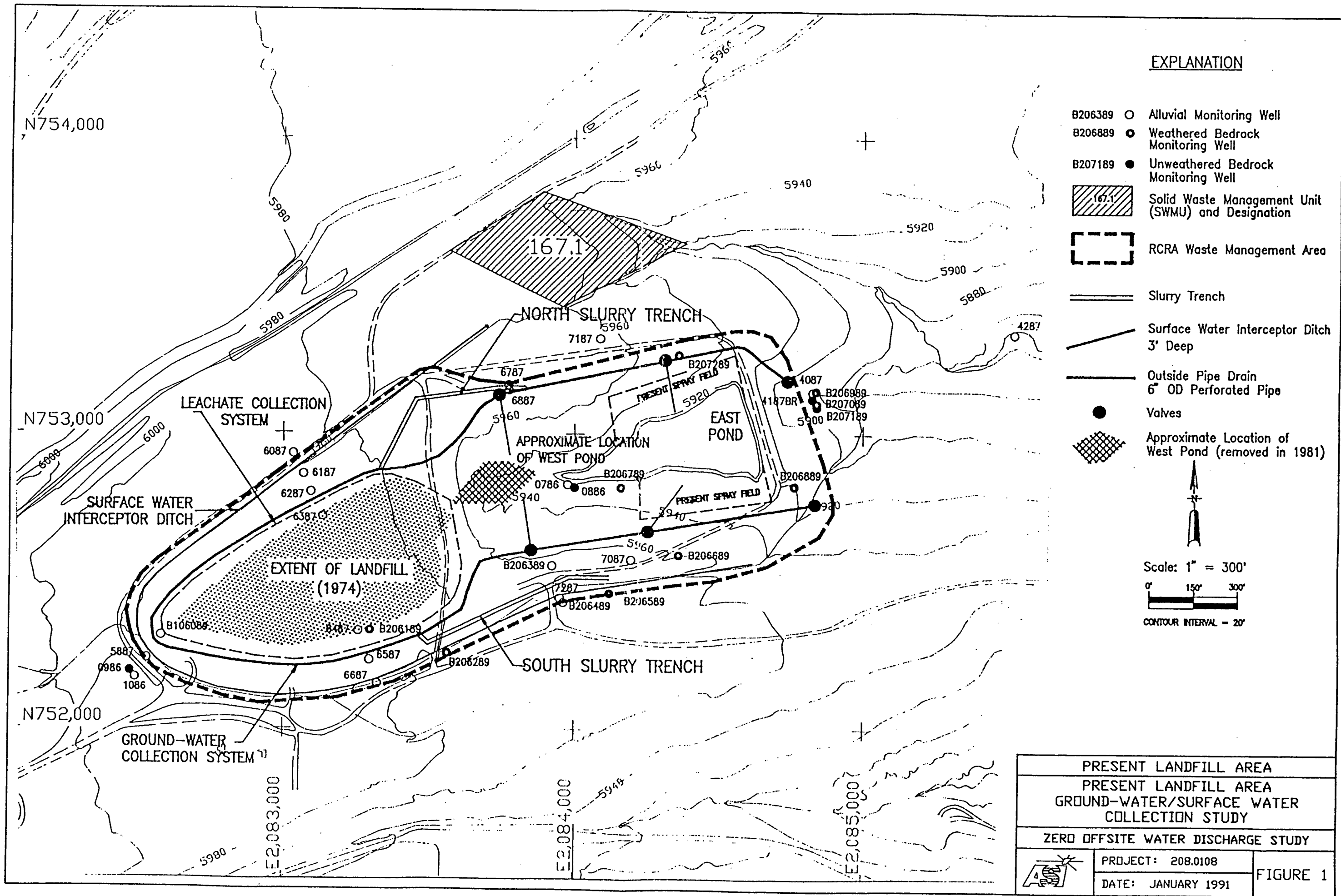
January	0
February	0
March	10
April	17
May	20
June	24
July	29
August	30
September	22
October	14
November	0
December	<u>0</u>

TOTAL	166 cm Annual Pan Evaporation
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(65.4 inches Annual Pan Evaporation)

Actual evaporation is approximately 0.7 of Pan Evaporation.* Therefore, actual evaporation is approximately 116 cm per year or 45.8 inches per year.

* Source: Hazardous Waste Land Treatment, SW-874, USEPA, Municipal Environmental Research Laboratory, Office of Research and Development, Cincinnati, Ohio, April 1983.



When Eq. (22-22) is used in industrial-waste treatment, allowance must be made for organic loading and treatability of individual process wastes. Hence, it is advisable to develop pilot-plant information on filter application before final design.

Hydraulic surface loadings should always be greater than 70 mgad, to provide continuous washing or scouring of the filter. Unlike high-rate and low-rate filters, application of wastewater must be continuous.

Equations have been developed by engineers concerned with design and performance of trickling filters. These equations include the Velz formula (1948), Schulz formula (1960), Eck-enfelder formula (1963), and Galler and Gotaas formula (1965). Each formula incorporates the influences that the investigators believed to be of primary importance.

See also *Filtration* in Art. 22-31.

(Metcalf & Eddy, Inc., "Wastewater Engineering," McGraw-Hill Book Company, New York; "Filtering Materials for Sewage Treatment Plants," Manual 13, and "Sewage Treatment Plant Design," Manual 36, American Society of Civil Engineers; G. M. Fair, J. C. Geyer, and D. A. Okun, "Water and Wastewater Engineering," John Wiley & Sons, Inc., New York; "Wastewater Treatment Plant Design," MOP8, Water Pollution Control Federation, Washington, D.C.)

22-20. Activated-Sludge Processes

An activated-sludge process is a biological treatment in which a mixture of wastewater and a sludge of microorganisms is agitated and aerated and from which the solids are subsequently removed and returned to the aeration process as required.

Passing air bubbles through wastewater coagulates colloids and grease, satisfies some of the BOD, and reduces ammonia nitrogen a little. Aeration also may prevent wastewater from becoming septic in a following sedimentation tank. But if wastewater is mixed with previously aerated sludge and then aerated, as is done in activated-sludge methods, the effectiveness of aeration is considerably improved. Reduction of BOD and suspended solids in the conventional activated-sludge process, including presettling and final sedimentation, may range from 80 to 95% and of coliforms, from 90 to 95% (Table 22-7). Furthermore, cost of constructing an activated-sludge plant may be competitive with other types of treatment plants producing comparable results. Unit operating costs, however, are relatively high.

The activated-sludge method is a secondary biological treatment employing oxidation to decompose and stabilize the putrescible matter remaining after primary treatments. Other oxidation methods include filtration, oxidation ponds, and irrigation. These oxidation methods bring organic matter in wastewater into immediate contact with microorganisms under aerobic conditions.

In a conventional activated-sludge plant (Fig. 22-15a), incoming wastewater first passes through a primary sedimentation tank. Activated sludge is added to the effluent from the tank, usually in the ratio of 1 part of sludge to 3 or 4 parts of settled sewage, by volume, and the mixture goes through an aeration tank. In that tank, atmospheric air is mixed with the liquid by mechanical agitation, or compressed air is diffused in the fluid by various devices: filter plates, filter tubes, ejectors, and jets. In either method, the sewage thus is brought into intimate contact with microorganisms contained in the sludge. In the first 15 to 45 min, the sludge adsorbs suspended and colloidal solids. As the organic matter is adsorbed, biological oxidation occurs. The organisms in the sludge decompose organic nitrogen compounds and destroy carbohydrates. The process proceeds rapidly at first, then falls off gradually for 2 to 5 h. After that, it continues at a nearly uniform rate for several hours. Generally, the aeration period ranges from 6 to 8 or more hours.

The aeration-tank effluent goes to a secondary sedimentation tank, where the fluid is detained, usually from 1½ to 2 h, to settle out the sludge. The effluent from this tank is completely treated and, after chlorination, may be safely discharged.

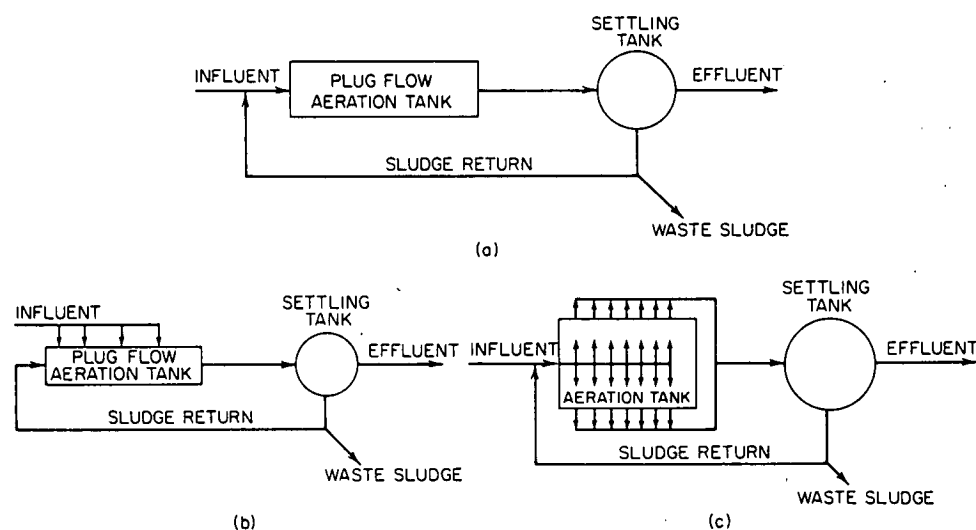


Fig. 22-15. Schematics of activated-sludge processes: (a) Conventional; (b) step aeration; (c) complete mix. (From "Environmental Pollution Control Alternatives: Municipal Wastewater," Environmental Protection Agency, Cincinnati, Ohio.)

About 25 to 35% of the sludge from the final sedimentation tank is returned for recirculation with incoming sewage. Sludge should not be detained in the tank. Frequent removal (at intervals of less than 1 h) or continuous removal is necessary to avoid deaeration.

Overflow rates for final sedimentation normally range from about 800 gal/(ft² · day) for small plants to 1000 for plants of over 2-mgd capacity. Weir loadings preferably should not exceed 10,000 gal/(lin ft · day). When tank volume required exceeds 2500 ft³, multiple sedimentation tanks are desirable.

Multiple aeration tanks are required when total tank volume exceeds 5000 ft³. Aeration tanks in which compressed air is used generally are long and narrow. To conserve space, the channel may be turned 180° several times, with a common wall between the flow in opposing directions. An air main is generally run along the top of the wall to feed diffusers (Fig. 22-16a and b) or porous plates (Fig. 22-16c) along its length. The air sets up a spiral motion in the liquid as it flows through the tanks. This agitation reduces air requirements.

Width of channel ranges from 15 to 30 ft. Depth is about 15 ft.

Dissolved oxygen should be maintained at 2 ppm (mg/L) or more. Air requirements normally range from 0.2 to 1.5 ft³/gal of wastewater treated. Most state authorities require a minimum of 1000 ft³ of air per lb of applied BOD per day.

Mechanical aeration may be done in square, rectangular, or circular tanks, depending on the mechanism employed for agitation. In some plants, the fluid may be drawn up vertical tubes and discharged in thin sheets at the top, or the liquid may pass down draft tubes while air is bubbled through it. In both methods, agitation at the surface produced by the movement of the liquid increases aeration. Detention periods generally are longer, 8 h or more, than for tanks with diffused air.

Several modifications of the activated-sludge method, seeking to improve performance or cut costs, are in use. These include modified, activated, tapered, step, and complete-mix aeration, and the Kraus, biosorption, and bioactivation processes.

Modified aeration decreases the aeration period to 3 h or less and holds return sludge to a low proportion. Results are intermediate between primary sedimentation and full secondary treatment.

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(6.0 or less) and pounds per day of BOD per 1000 ft³/h of aeration (1.2 or less). About 1.5 ft³ of air per gal of flow is required. Overall plant efficiency may be about 90% BOD removal, with a higher percentage removal of suspended solids.

See also Art. 22-28.

(H. W. Parker, "Wastewater Systems Engineering," Prentice-Hall, Inc., Englewood Cliffs, N.J.)

22-22. Sludge Treatment and Disposal

Sludge comprises the solids and accompanying liquids removed from wastewater in screening and treating it. Solids are removed as screenings, grit, primary sludge, secondary sludge, and scum. Often sludge treatment is necessary to make possible safe, economical disposal of these wastes. The treatment to be selected depends on quantity and characteristics of the sludge, nature and cost of disposal, and cost of treatment.

Screenings are putrescible and offensive. They may be disposed of by burning, burial, grinding and return to sewage, or grinding and transfer to sludge digester. The quantity of screenings is variable and dependent on sewage characteristics. Coarse screenings may range from 0.3 to 5 ft³/million gal. Fine screenings may range from 5 to 35 ft³/million gal.

Sand and other gritty materials also may be present in widely varying amounts. Normally, the volume will be between 1 and 10 ft³/million gal.

Sludge varies in quantity and characteristics with the characteristics of the sewage and plant operations. Usually, more than 90% is water containing suspended solids with a specific gravity of about 1.2. Roughly, there may be about 0.20 lb of these solids per capita daily in sanitary sewage; 0.22 lb if a moderate amount of industrial wastes is present; 0.25 lb in effluents of combined sewers if considerable industrial wastes are present; and 0.32 to 0.36 lb if the sewage contains ground garbage also.

Primary sludge, derived from sedimentation tanks or the influent of digestion chambers of Imhoff tanks, is putrescible and odorous. It is composed of gray, viscous identifiable solids and has a moisture content of 95% or more. Primary treatment of 1 million gal of sewage may produce about 2500 gal of this sludge.

Trickling filter sludge is black or dark brown, granular or flocculent, and partly decomposed. It is not highly odorous when fresh. Moisture content may be about 93%. Passage of 1 million gal of sewage through a trickling filter may produce about 500 gal of this sludge.

Activated sludge is dark to golden brown, granular or flocculent, and partly decomposed. It has an earthy odor when fresh. Moisture content may be about 98%. Influent to an activated-sludge plant may yield about 13,500 gal of waste sludge per million gal.

Chemical-precipitation sludge may have a solids content more than double that of sludge from primary sedimentation. Normally, chemical precipitation from 1 million gal of sewage will yield about 5000 gal of sludge with moisture content of 95%.

Digested sludge, from septic, Imhoff, or separate digestion tanks, is very dark in color and has a homogeneous texture. When wet, it has a tarry odor. Roughly, treatment of 1 million gal of sewage will produce 800 gal of digested sludge with a moisture content of about 90%.

The sludges removed in wastewater treatment may contain as much as 97% water. The objective of sludge treatment is to separate the solids from the water and return that water to a wastewater-treatment plant for processing. Sludge treatment may require:

1. **Conditioning.** Sludge is treated with chemicals or heat so that the water may be readily separated.
2. **Thickening.** Removal of as much water as possible by gravity or flotation.
3. **Stabilization.** Processes known as sludge digestion are employed to stabilize (make less odorless and less putrescible) the organic solids in the sludge so that they can be

handled or used as soil conditioners without creating a nuisance or health hazard.

4. **Dewatering.** Further removal of water by drying the sludge with heat or suction.

5. **Reduction.** The solids are converted into a stable form by incineration or wet oxidation processes.

Sludge conditioning may employ any of several available methods to facilitate separation of the water from the solids in sludge. One method is to add a coagulant, such as ferric chloride, lime, or organic polymers, which cause the solids to clump together. Another method is to first grind the sludge and then heat it to between 350 and 450°F under pressures of 150 and 300 psi in a reactor. Under these conditions, the water contained in the solids is released. The sludge is fed from the reactor to a settling tank, where the solids are concentrated before the dewatering step. Still another conditioning method is to apply heavy doses of chlorine under pressures of 30 to 40 psi.

Sludge thickening usually is accomplished in one of two ways: settlement, or gravity thickening, or flotation thickening. Simple and inexpensive, gravity thickening is essentially a sedimentation process, employing a tank similar in appearance and action to a circular clarifier used in primary and secondary sedimentation (Fig. 22-18a). Best results are obtained with sludges from primary wastewater treatment. In flotation thickening (Fig. 22-18b), air is injected into the sludge under pressures of 40 to 80 psi. Containing large amounts of dissolved air, the sludge flows into an open tank. There, under atmospheric pressure, the dissolved air

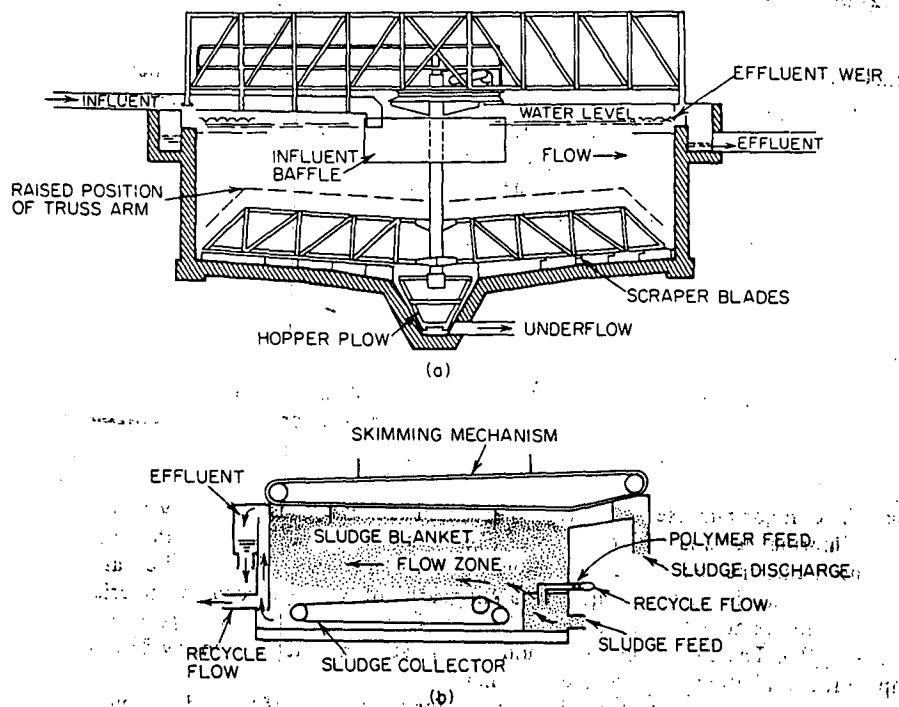


Fig. 22-18. Cross sections of sludge-thickening equipment: (a) Gravity thickener; (b) flotation thickener.

22-29. Activated Biofilters

Another means for attaining wastewater secondary-treatment quality is the activated-biofilter process. It employs a combination of fixed microbial growth and a high concentration of suspended growths. The fixed growth occurs on the redwood slats comprising the filter media of a trickling filter about 14 ft deep. The high concentration of suspended growths is developed by recirculating the process effluent and settled sludge from a secondary clarifier (Fig. 22-28).

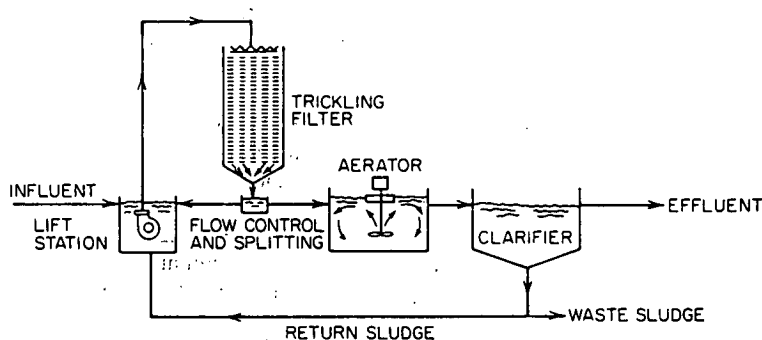


Fig. 22-28. Schematic of activated-biofilter process.

Oxygen is supplied as the wastewater splashes between the redwood slats and by movement of the wastewater in a film across the microbial growth on the slats. To provide a high degree of treatment, an aeration tank may be installed between the filter and the secondary clarifier, as shown in Fig. 22-28. With about 1 h of supplemental aeration, the process can produce an effluent with less than 20 mg/L of BOD and suspended solids. Requiring less area than a trickling-filter plant, activated biofilters provide stable operation and few system upsets. They can be installed before existing activated-sludge basins to improve plant efficiency or increase plant capacity.

22-30. Disinfection

The last step in secondary treatment of wastewater is disinfection of the effluent to kill pathogenic (disease-causing) bacteria and viruses. For the purpose, chlorine or ozone is generally used.

Chlorination ■ The major purpose of chlorinating treated wastewater is to destroy pathogenic organisms. Chlorine demand of domestic or industrial wastewater is the difference between the amount of chlorine added and the residual after a short time. This interval usually is taken as 15 min since this is the time required to kill nearly all the objectionable bacteria. Sufficient chlorine should be added to treatment effluent to satisfy the demand and provide a residual of 2 ppm (mg/L). The contact period should be at least 15 min at peak hourly flow or maximum pumping rate and 30 min at average daily flow.

The following dosages, ppm or mg/L, may be required for disinfection of treated wastewater: primary sedimentation effluent, 20 or more; trickling-filter-plant effluent, 15; activated-sludge-plant effluent, 8; and sand-filter effluent, 6. Such disinfection is desirable and often mandatory where discharge of the effluent may pollute water supplies, shellfish beds, or beaches.

The 5-day BOD of wastewater is reduced about 2 ppm for each ppm of chlorine added. A BOD reduction of 15 to 35% may be expected with residuals of 0.2 to 0.5 ppm after 10 min.

Chlorinators usually are used to feed chlorine to the treatment effluent. Chlorine gas normally is dissolved in water, and the solution is pumped into the effluent in measured amounts, proportional to the flow. In small plants and some large plants, hypochlorinators may be used. These may feed sodium hypochlorite (laundry bleach) or calcium hypochlorite.

Chlorination should be done in a baffled contact tank, unless there will be sufficiently long contact time in a conduit or outfall before the chlorinated effluent is discharged. The accuracy of the chemical feeders should be checked daily by determining the weight of chlorine or hypochlorites used. In addition, the efficacy of dosages applied should be checked frequently by bacteriological tests.

Chlorine also may be useful in preventing odors at wastewater treatment plants. For this purpose, it may be added on line or to primary influent. Chlorination before primary sedimentation is not detrimental to sludge digestion.

Other uses of chlorine include neutralization of hydrogen sulfide, or prevention of its formation, where it may corrode concrete sewerage or structures; increasing the efficiency of air in grease removal in skimming tanks; control of ponding and filter-fly larvae on trickling filters; conditioning of sludge before dewatering; and treatment of industrial wastes.

Some states place rigid restrictions on discharge of effluents containing chlorine that may form trihalomethane, a potential cancer-causing agent, in receiving waters used for drinking. A tentative maximum contaminant level of 100 mg/L has been proposed. Check with state authorities for limitations on free available chlorine in discharges.

For example, the rules of the Florida Department of Environmental Regulation, established in 1982, state:

The department is cognizant of the potentially harmful effects of chlorine used in conjunction with wastewater treatment and encourages use of alternative disinfection methods. . . . Dechlorination may be required by the department to ensure that applicable water quality standards will be met. . . . Maximum permissible residual levels in the effluent immediately following chlorination and the necessity for dechlorination shall be established as appropriate based upon information . . . in the engineering report regarding impacts on the receiving surface or ground water. . . . A basic level of disinfection shall result in not more than 200 fecal coliform values per 100 ml of effluent sample. Where chlorine is utilized for disinfection, maintenance of 0.5 mg/liter minimum total chlorine residual after 15 min contact time at maximum daily flow, or after 30 min contact time at average daily flow, whichever provides the higher level of public-health protection, shall be accepted as evidence that the microbiological criterion will be met. . . .

Dechlorination, when required, may be accomplished by ion exchange, filtering through activated carbon, or injection of alum, sodium bisulfite, sodium sulfite, or sulfur dioxide.

Ozonation • Ozone, produced at point of use by passing dry air between two high-voltage electrodes, is an alternative to chlorine for disinfection of treated wastewater. It has the advantage that the only residual left in the water is dissolved oxygen. The cost of ozone, however, is usually larger than the cost of chlorine for accomplishing the same degree of treatment.

Ultraviolet Disinfection • Another alternative to chlorine is use of ultraviolet light to kill bacteria and viruses. The wastewater is passed over horizontal glass cylinders, inside of which are ultraviolet-light sources. A circular windshield wiper keeps the tube surfaces clean.

(American Water Works Association, Inc., "Water Quality and Treatment," McGraw-Hill Book Company, New York; G. C. White, "Disinfection of Wastewater and Water for Reuse," McGraw-Hill Book Company, New York; and G. C. White, "Handbook of Chlorination," Van Nostrand Reinhold Company, New York.)

are desired, after secondary treatment, coagulation-sedimentation, and filtration. This combination of processes can produce a colorless, odorless effluent, free of bacteria and viruses, with a BOD of less than 1 mg/L and a COD of less than 10 mg/L, suitable for many reuse purposes. In any case, the wastewater to be treated is passed through beds of granular carbon particles, about 0.8 mm in diameter, arranged like a gravity filter or in columns 20 to 25 ft deep. Time for contact between carbon and wastewater may range from 20 to 40 min.

For the IPC process, the raw wastewater is usually first coagulated and settled, sometimes also filtered, then subjected to carbon adsorption. The result is a degree of treatment better than biological secondary but not as good as that achieved with a combination of secondary treatment and carbon adsorption.

Nitrogen Reduction Treatments ■ Nitrogen contained in wastewater is converted into ammonia during conventional biological secondary treatment. Ammonia, although not toxic to humans, is toxic to fish and is objectionable also because it consumes dissolved oxygen, corrodes copper fittings, and increases the amount of chlorine needed for disinfection. The amount of ammonia retained in wastewater can be reduced by biological or physical-chemical methods. The latter include ammonia stripping, selective ion exchange, and breakpoint chlorination. Both carbon adsorption and nitrogen reduction should be tried out on the wastewater to be treated in a pilot plant before the prototype is built.

Biological nitrification-denitrification first biologically converts the ammonia nitrogen into nitrates (nitrification). This is accomplished by injection into the wastewater of sufficient oxygen (about 4.5 lb per pound of ammonia nitrogen in the wastewater). The next step is denitrification, biological conversion of the nitrates to gaseous nitrogen, which escapes to the atmosphere. Denitrification can be performed in an anaerobic activated-sludge process (suspended growth system) or a fixed-film system. In this step, an oxygen-demand source, such as methanol, is added to the wastewater because conversion of nitrates to gaseous nitrogen will take place only when there is a demand for oxygen in the absence of oxygen; this condition is not likely to exist after nitrification.

Ammonia stripping is a physical-chemical method for removing gaseous ammonia. It comprises three basic steps: (1) Raising the pH of the water with lime to form gaseous ammonia. (2) Cascading the water down a stripping tower, which resembles a conventional cooling tower, to release the gas. (3) Circulating large quantities of air through the tower to carry the ammonia into the atmosphere.

Selective ion exchange removes ammonia nitrogen from wastewater by exchanging ammonia ions for sodium or calcium ions contained in an insoluble exchange material. The specific ion-exchange material used in this process is clinoptilolite, a naturally occurring zeolite.

Breakpoint chlorination removes nitrogen by forming compounds that eventually are converted to gaseous nitrogen. To achieve the conversion, about 10 mg of chlorine must be added per mg of ammonia nitrogen in a liter of wastewater. As a result, about 40 or 50 times more chlorine is required than that normally used in a wastewater plant for disinfection only.

(R. L. Culp, G. M. Wesner, and G. L. Culp, "Advanced Wastewater Treatment," Van Nostrand Reinhold Company, New York.)

22-32. Industrial Waste Treatment

The treatment of industrial wastes (see Art. 22-2) is highly specialized. Selection of treatment processes must be engineered to the peculiar characteristics of a process waste. It is desirable, whenever possible, to reduce the volume of wastewater requiring treatment or to separate wastes requiring intensive treatment from those requiring little or no treatment. Cooling water, for example, can be segregated from high-strength wastes, thereby reducing the size of the treatment plant.

22-31. Advanced Wastewater Treatment

Wastewater secondary treatment and disinfection generally produce an acceptable effluent for disposal on land or a large body of water in that more than 85% of the BOD and suspended solids and nearly all pathogens are removed from the wastewater. This treatment, however, usually removes only small percentages of some pollutants, such as phosphorus, nitrogen, soluble COD, and heavy metals. Where these pollutants in an effluent are of major concern, advanced, or tertiary, wastewater treatment should be applied. The following processes are capable of improving the effluent from secondary treatment to the degree that it is adequate for many reuse purposes.

Coagulation-Sedimentation ■ When used as a tertiary treatment, coagulation-sedimentation improves overall treatment of wastewater by providing a means for removal of the excessive quantities of solids that may escape occasionally from the biological processes. Coagulation-sedimentation also may remove high percentages of phosphorus, heavy metals, bacteria, and viruses.

In this treatment, coagulants, such as lime, alum (aluminum sulfate), or ferric chloride, are injected into the wastewater. They speed settlement of the solids in the wastewater because they cause the solids to clump together. This action is accelerated by addition of a polymer as a settling aid and by flocculating, or slowly stirring, the wastewater. After flocculation, the wastewater flows to a sedimentation tank, or clarifier, where the solids settle to the bottom, from where they are removed (Fig. 22-29).

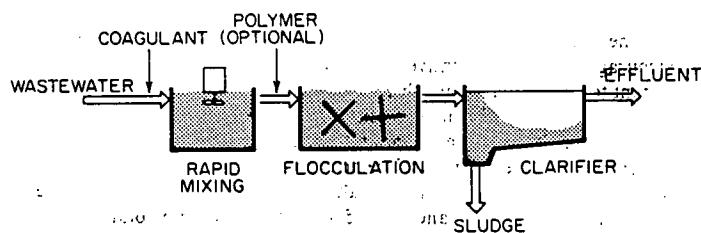


Fig. 22-29. Schematic of coagulation-sedimentation process.

Filtration ■ In tertiary treatment, filtration is used to remove suspended solids from a secondary effluent or from the effluent from a coagulation-sedimentation process. Filtration may be performed in an open concrete structure by gravity flow or in steel vessels by pressure. Plain filtration (Art. 22-19) can reduce the suspended solids in activated-sludge effluent from 50 to 75%. Effective filtration of the effluent from tertiary coagulation-sedimentation can reduce phosphorus to 0.1 mg/L or less and eliminate suspended solids.

The filters may be multimedia, composed of a mixture of different materials, such as coal, sand, and garnet. The filters are coarse in the upper layers and become uniformly finer with depth. The wastewater is passed downward during normal operation, but flow is reversed to clean the filters.

Carbon Adsorption ■ Activated carbon has the capacity for removing from wastewater refractory organics, organic substances resistant to biological breakdown, which are responsible for the color of secondary effluent. These substances adhere to the surfaces of the porous carbon particles and can be removed by heating the carbon in a furnace with very low levels of oxygen. The activated carbon can then be reused.

Carbon adsorption may be applied as an independent physical-chemical (IPC) treatment, eliminating biological secondary wastewater treatment, or where very high degrees of treatment

tele conference

DATE: 10-7-98

RE: STP2 + B5 Direct Discharge

FROM: J. Hill / KH

B5 direct discharge -

dam safety

past CRO3 incident → knowledge

only \$200K / yr

QUESTIONS

① ↑
STP
inflow +
GW +
storms

STP2 -

flexibility

eliminate flow to B-ponds

high flow conditions

② Design
Basis for
Walnut Cr
Res.

DIS -

inventory

material unaccounted for

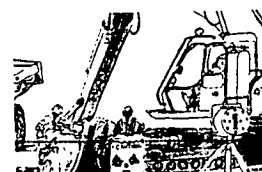
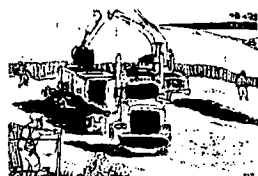
Pa in ducts

DOE Issues -

April + Rau

Option B

CWQCC



Thoughts on Approach to Pond Ops Plan

Hill
10-8-98

- ① 5000 pci/L detector (RT Pu)
- ② procedures to notify STP
- ③ STP 2 available
- ④ B5 direct discharge
- ⑤ routine batching
- ⑥ major events → divert
- ⑦ critical moment / high risk activity
↳ routine batching

RFCA SOURCE CONTROL ALTERNATIVES ANALYSIS COST ESTIMATE

DETENTION POND

Reference: "Rocky Flats Plant, Drainage and Flood Control Master Plan," Table, IV-5, Page IV-11, April 1992.

The runoff area will be considered the Great Western Reservoir Basin, West of Indiana Street, as delineated in the reference. Present development conditions, rather than future development conditions, will be assumed.

The design storm event is 100-year, 6-hour (296 acre-feet). Added to this runoff is the combined discharge from ponds A-4 and B-5 for a 30-day duration (230 acre-feet). Total = 526 acre-feet.

**Total Estimated Flow 2.24E+07 ft³
526 acre-feet**

The 25-year, 6-hour event + pond = **413 acre-feet**
(Same reference)

ratio of 100 year to 25-year event = **1.27**

Use this ratio to estimate 100-year event + pond discharge

Construction Costs

					Operating		Total
					Costs	(Present	
Storm		Comp-	Lining/	Outlet/		Value)	Pond
Event	Stripping	action	Rip Rap	Appurt-	Total		Costs
				enances	Constr.		
25-year	\$542,361	\$152,778	\$3,687,790	\$500,000	\$4,882,929	\$298,557	\$5,181,486
100-year	\$688,799	\$194,028	\$4,683,493	\$635,000	\$6,201,319	\$379,168	\$6,580,487 <-----

copy to: Ian Paton

WWE
MEMORANDUM

To: Dave, Jon, Wayne, Teresa, and Greg

From: Pete Waugh

Date: August 21, 1998

Re: Hydrologic Basis of Design for Rocky Flats Alternatives Analysis
Supersedes August 10, 1998 Memorandum

The purpose of this memorandum is to present the hydrologic basis of design for the Rocky Flats alternatives analysis. The hydrologic basis of design was developed based upon discussions with Bill Hayes, Ian Paton, and David Daboll of RMRS and a review of DOE policy. While the hydrologic design basis described in this memorandum may not be totally applicable to all of the various alternatives, a consistent basis of design must be used to allow comparison of the alternatives.

The facilities should be designed to manage stormwater runoff from the 25-year, 6-hour storm event (assuming current basin development conditions) plus the baseflow in the creeks. The storm flow runoff is taken from the *Rocky Flats Plant Drainage and Flood Control Master Plan*, April 1992. The baseflow data are developed from information provided by Ian Paton in a memorandum dated August 6, 1998.

The hydrologic design criteria for Walnut Creek at Indiana Street are as follows: $Q_{25} = 1400$ cfs, $V_{25} = 183$ acre-feet, baseflow = 660 acre-feet annually with a 30-day maximum flow of 230 acre-feet. The volume to be detained (assuming a 30-day detention time) is 183 acre-feet + 230 acre-feet = 413 acre-feet. For active treatment, the rate of treatment must be $660/12 + 413/2$ months = 262 acre-feet per month (assuming a 60-day release time).

The hydrologic design criteria for Woman Creek at Indiana Street are as follows: $Q_{25} = 830$ cfs, $V_{25} = 162$ acre-feet, baseflow = is undetermined at this time. This value will be determined after pond C-2 flows are provided to WWE.

There is a significant amount of additional hydrologic data available for the plant site if needed for design of any of the alternatives. This includes stormwater runoff flow and volume for the 2-, 5-, 10-, 25-, 50-, and 100-year storm events at numerous locations throughout the plant site.

Memorandum to Dave, Jon, Wayne, Teresa and Greg
August 21, 1998
Page 2

Additionally, there are data available for precipitation, soil types, drainage and flood control structures, floodplains, and other drainage and flood control-related issues.

cc: File 901-004.820, Task 1
Ken Wright
Trish Flood

C:\901-004\820\ard\task 1\basisofofdesign2.pdw.doc

The individual sub-basins ranged in size from 7 acres to 1734 acres. The selected sub-basins lying on the plant site were smaller in size than those outside the plant site to provide opportunity for a more detailed definition of flows.

The following criteria were used in the development of the models:

1. Natural drainage channels and man-made facilities specifically constructed for the purpose of water management or flood control were modelled. The Walnut Creek Diversion Canal, the South Interceptor Ditch, and an unnamed ditch immediately north of the East Entrance Road were modelled. Other man-made ditches were ignored in the modelling. To allow for flexibility in the modelling effort, the A-, B- and C-series ponds were assumed full at the start of the precipitation event with no attenuation of flow through the ponds.
2. Ponds, lakes, and depressions other than the A-, B-, and C-series of ponds, the Landfill Pond, Great Western Reservoir, and Standley Lake were not separately modelled. They were included in the characteristics of the basin in which they are located.
3. There is an insignificant amount of water spilled from Coal Creek to ditches that cross the plant site. This is consistent with field observations of the ditch headgates and evaluation of geomorphological conditions and ditch banks (further discussed in Section V) and analysis of Coal Creek floodplain hydraulics.
4. For the purposes of master drainage planning, the Core Area was divided into main sub-basins according to the natural overland flow path of runoff water. Minor system storm sewers and small culverts were not modelled as part of the major drainage system. A detailed analysis of the Core Area that includes the initial (local) drainage system elements is included in Section VII of this Master Plan.
5. For the purposes of master planning, the downstream end of the study area is Indiana Street. Inflow hydrographs to Standley Lake and Great Western Reservoir were computed and found to be similar to the approved UDFCD master drainage plan for Big Dry Creek (Greiner Engineering, 1986).

6. It was assumed that the Walnut Creek Diversion Dam, the Walnut Creek Diversion Canal, the South Interceptor Ditch, and the Woman Creek Diversion Dam would have sufficient hydraulic capacity to convey the runoff from the 100-year, 6-hour precipitation event. This was verified as correct after comparison of the calculated peak flow at these locations to the calculated hydraulic capacity of each of the facilities.

Keith - Additional info

DD

Results

The results of the hydrologic analysis described in this section are presented in tables and figures for ready reference and comparison of rates of flow and volume of runoff for each frequency of occurrence. Individual hydrological design points are located throughout each major basin from the upper portion of each basin easterly to Indiana Street.

The range (2- to 100-year) of peak flood flows for each sub-basin is based upon the 6-hour precipitation distribution. The 2-hour and the 6-hour distribution resulted in the same peak rate of runoff for each sub-basin because they are identical for the first 2 hours. The volumes of flood runoff are larger for the 6-hour precipitation distribution for developed basins such as in the Core Area. [For purposes of drainage master planning at the Rocky Flats Plant site, the 6-hour design storm is utilized.

The 24-hour, 4-day and 10-day upslope storms were analyzed. The analysis demonstrated that the long-duration storms were not critical to the rate of runoff. The long duration storms yield a higher volume of runoff only for basins with high percentage of imperviousness; other basins yield a lower volume of runoff.

All given flow rates and hydrographs assume that ponds and reservoirs are full and that there is no diminution of flow caused by the ponds and reservoirs. This assumption, while conservative, provides the basis and opportunity to analyze ponds and reservoirs independently and under different operating scenarios.

CUHP Model Results. The peak flow, runoff volume, peak flow per unit area, and unit runoff generated by CUHP for present development conditions for each of the delineated sub-basins are presented in Appendix IV-B. The peak flow and runoff volumes are significantly dependent on the percentage imperviousness and soil infiltration characteristics.

$$\begin{array}{r}
 27 \\
 3 \\
 \hline
 69
 \end{array}
 \quad
 \begin{array}{r}
 16 \\
 4 \\
 \hline
 67
 \end{array}
 \quad
 \begin{array}{r}
 84 \\
 137 \\
 \hline
 164
 \end{array}$$

$$\begin{array}{r}
 31 \\
 \hline
 164
 \end{array}$$

19%

$$\begin{aligned}
 &15 \text{ ppm} \times 120,000 \text{ gpd} \times 3. \\
 &\underline{- 2 \text{ ppm}} \\
 &13 \text{ ppm normal}
 \end{aligned}$$

$$13 \times 10^{-6} \text{ lb(P)/lb} \times 8.3 \text{ lb/gal} \times 120,000 = 13 \text{ lb(P)}$$

$$\begin{aligned}
 &\underline{13 \text{ lb(P)}} \approx 68 \text{ lb TSP} = 70 \text{ lbs TSP} \\
 &19\% \text{ P/TSP}
 \end{aligned}$$

APPENDIX A

SPILLS

Provided in this appendix is a list of RFETS spills from September 1997 to September 1998.

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DATE	Substance	Amount	Location	Media Released to	Action Taken	Preventative Action/Plan
OCT '97						
10-8-97	Cooling tower water leaking from underground pipe	Estimated total 100-200 gallons	North of B776 near B701	Soil	Underground leaking pipe was located and the system isolated until repairs could be completed.	The underground pipe was repaired and water use monitored to identify any additional leaks.
10-24-97	Oxyaclic acid (powder) from original bag.	1 cup	B663 laydown yard	Soil	Powder and soil removed.	Directed workers to inspect the bags before handling and use care when moving bags.
10-28-97	Gasoline from private vehicle	1 quart	Parking lot west of PAC# 3	Pavement	Cleaned up the release with rags.	Instructed owner to check vehicle.
10-28-97	Oil from vehicle	< 1 pint	Parking lot north of PAC# 3	Pavement	Cleaned up the release with rags.	Instructed area building and garage to check vehicle and equipment.
10-28-97	Hydraulic oil from front-end loader tractor	1 pint	B774 north dock	Pavement	Cleaned up the release with rags.	Instructed operator to check vehicle.
10-28-97	Gasoline from private vehicle	0.5 gallon	Parking lot west of PAC# 1	Pavement	Cleaned up the release with rags.	Instructed owner to check vehicle.
10-28-97	Process waste (rad) backed up in filters	10 gallons	B444, 1 st floor	Containment	Rad and chemical screened. Isolated system. Cleaned up release.	Inspected system and completed repairs.
10-29-97	Mastic remover "Mastisov Plus"	5 oz.	B663 laydown yard, near east shed	Soil	Rad and chemical screened. Cleaned up spill and removed contaminated soil.	Inspected the remaining containers.
NOV '97						
11-3-97	Hydraulic fluid from backhoe	0.5 gallon	South end of T690 area	Soil	Cleaned up the release and contaminated soil.	Instructed operator to check equipment prior to beginning operations.
11-3-97	Hydraulic fluid from backhoe	1 gallon	South of B779	Soil	Cleaned up the release and contaminated soil.	Instructed garage to check equipment.
11-9-97	Snowmelt leaked into RCRA storage unit #371.1A	1-2 gallons	B371, Room 3159 to 3189	Floor/containment	Rad and chemical screened. Diverted snowmelt. Cleaned up the water (snowmelt).	Repaired building opening to divert all snowmelt run-off.
11-14-97	Hydraulic fluid from snowplow	1 gallon	Central Ave. east side of	Pavement	Cleaned up the release and contaminated soil.	Instructed owner/operator to check all vehicles and equipment prior to

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DATE	Substance	Amount	Location	Media Released to	Action Taken	Preventative Action/Plan
			plant			bringin on Site and beginning operation.
11-17-97	Water (nonrad) frozen water line break	< 5 gallons	T12 photo lab northwest of B551	Floor/containment	Rad and chemical screened. Pipe isolated. Water cleaned up.	Pipe system inspected and repairs completed.
11-24-97	Hydraulic oil from street sweeper	10 gallons	Parking lot near B460	Pavement	Cleaned up the release and contaminated soil.	Instructed garage to check equipment.
DEC '97						
12-19-97	Diesel fuel – overflow of emergency generator fuel tank.	6 gallons	PAC #2	Soil	Cleaned up the release and contaminated soil.	Installed overflow protection and reviewed the operating procedures with delivery personnel.
JAN '98						
1-12-98	Water (nonrad) from cooling tower broken underground pipe	Estimated 500 gallons	South of B707	Soil	Water sampled and rad/chem screened. Pooled water pumped into tanker truck and the remaining water dissipated into the soil. The broken underground pipe was repaired.	Monitor cooling system.
1-14-98	Water (nonrad) from cooling tower	1000 gallons inside B708, 200 gallons outside B708	B708	Containment and Pavement/ Soil	Water sampled and rad/chem screened. Water in bldg. went to process waste drain. Water outside of bldg. could not be collected and dissipated into pavement/soil. Piping system checked and repaired.	Monitor cooling system.
1-16-98	Process waste from slow draining line that backed up into sink and floor.	10 gallons	B881, Room 137	Containment / Floor	Waste liquid on floor was rad/chem screened and cleaned up. The waste liquid in sink slowly drained into process waste line. No further use of the process waste line was allowed.	Use of the bldg. process waste line was suspended until the entire process waste system was inspected and evaluated. Repairs and modifications to the system were completed.
1-18-98	“Incidental Water” – groundwater with 300 ppb TCE pumped through hose.	200 gallons of groundwater (0.35 g of TCE)	Parking lot west of PAC #1	Pavement/ Soil	Water sampled and rad/chem screened. Pooled water was pumped into holding tank. The rest of the water dissipated into soil. The “incidental waters” that accumulated in the manhole was pumped into holding tanks.	The pumping system was redesigned to replace the temporary system using the fire hose to permanent “hard” piping system.
1-19-98	Stain discovered around transformer	Estimated <1-2 gallons	Alley south of B776	Soil	Soil sampled and rad/chem screened. Recent work activity and historical records were	Monitor area for any additional staining. Checked other similar

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DATE	Substance	Amount	Location	Media Released to	Action Taken	Preventative Action/Plan
	(labeled non-PCB)				checked for possible releases.	transformers.
1-20-98	Ethylene glycol (antifreeze) from pipe during demolition	5-10 gallons	B123	Containment	Rad screened and cleaned up release. Drained remaining antifreeze from lines.	Checked other pipelines for freezing damage and reviewed pipe dismantling actions.
1-21-98	Process waste	1 gallon	B371, Rm 3701	Containment	Rad/chem screened and cleaned up release.	Daily inspections of area.
1-29-98	Mineral oil from new transformer (nonPCB)	½ cup	B130, Receiving Dock	Containment	Cleaned up the release and containerized the new transformer.	Instructed receiving dock personnel on how to inspect equipment at the receiving dock before accepting equipment.
1-29-98	Mercury from broken thermometer	1 teaspoon	B125, Door 3 South Dock	Containment	Cleaned up the release.	Instructed workers on safe handling techniques and moving equipment (thermometers).
FEB '98						
2-4-98	Oil from vehicle	1 cup estimated	Southwest of B122	Soil	Cleaned up the release. Removed stained soil.	Instructed owner to check vehicle.
2-13-98	Process waste	5 gallons	B887	Containment	Rad/chem screened and cleaned up release.	Inspected entire process waste line. Completed identified repairs. Continue daily inspections.
2-18-98	Water (nonrad) used to flush bermed area	200 gallons estimated	North of B371 near bermed product acid tanks	Soil	Rad/chem screened and cleaned up release.	Inspected area and rerouted snowmelt run-off.
* 2-21-98	Mixed hazardous waste from tank valve	5 fl. oz.	B771, Room 149	Containment	Rad/chem screened and cleaned up release. Due to rad and available trained workers the release was cleaned up 36 hr after discovered. Reported to CDPHE per RCRA permit.	Valve adjusted and inspected daily.
* 2-25-98	Mixed hazardous waste from tank valve	1 fl. oz.	B771, Room 149	Containment	Rad/chem screened and cleaned up the release. Due to possible rad and available trained workers the release was cleaned up 42 hrs after discovered. Reported to CDPHE per RCRA permit.	Valve readjusted and inspected daily.
MAR'98						

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DATE	Substance	Amount	Location	Media Released to	Action Taken	Preventative Action/Plan
3-3-98	Water (rad) from shower drain backup	<10 gal	B779	Containment	Rad/chem screened and cleaned up the release. Cleared drain.	Periodically checked drain.
3-5-98	"Incidental water" - groundwater in sump area	3 gallons	B885	Soil	Rad/chem screened and collected the accumulated "incidental" groundwater into tanker truck and sent to "incidental waters" treatment.	Monitored the area.
3-8-98	Water (nonrad) from broken fire suppression system line (fire sprinklers)	1200 gallons	B444, Room 212B	Containment	Rad/chem screened. Contained and controlled water. Cleaned up release by placing in the process waste drain.	Repaired and inspected entire line.
3-14-98	Gasoline from govt. vehicle	½ pint	Southeast corner of Tower 2	Soil	Cleaned up release and stained soil.	Cautioned driver to not overfill tank.
3-19-98	Oil sheen on street snow melt runoff water	<¼ cup from leaking private vehicles on street	North of B444 on Cottonwood Street	Pavement	Used absorbent tubes to soak up oil/water. Cleaned up the release.	Checked adjacent vehicles and contractors equipment in the area. Requested the contractor to check all equipment prior to bringing on Site.
APR '98						
4-2-98	Gasoline from private vehicle	1 –3 gallons	Parking lot east of B334	Soil	Cleaned up the release and stained soil.	Requested owner to check vehicle and not overfill tank.
4-7-98	Oil (rad) inside glovebox	½ pint	B779	Containment	Cleaned up the release.	Inspected lines.
4-13-98	*Groundwater being stored in modular storage tanks prior to treatment – broken pipe	200 gallons	North of B374	Soil	Rad/chem screened. Closed valves and collected the pooled water by pumping into tanker truck. Checked recent sample results indicating only slightly elevated nitrate levels. Groundwater was nonrad and nonhazardous.	Repair pipe/line and stabilize hillside.
4-14-98	Gasoline for motorized cart vehicle	< 1 pint	Courtyard north of T130D	Soil	Cleaned up the release and stained soil.	Garage inspected vehicle and cautioned not to overfill vehicles.
4-21-98	Oil/water (snowmelt)	< 1 gallon	Northeast of B777	Soil	Used absorbent and booms to cleaned up the release and stained soil.	Garage checked the vehicle.
4-22-98	Antifreeze from	< 1 pint	Parking lot	Pavement	Cleaned up the release with rags.	Requested owner to check vehicle.

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	private vehicle		south of PAC #2			
4-26-98	Diesel fuel from State Patrol Generator	<2 gallons	East of B60	Pavement/ Soil	Cleaned up the release and stained soil.	Notified State Patrol (owner) to check equipment.
4-28-98	Motor oil for portable generator	2 gallons	East of PAC # 1	Soil	Cleaned up the release and stained soil.	Garage checked and repaired generator.
MAY '98						
5-4-98	Fluorescent light bulbs (mercury)	5 bulbs (0.1 lbs.)	B61	Floor/ Containment	Cleaned up the release and debris.	Instructed workers to handle fewer bulbs at a time.
5-5-98	Gasoline from private vehicle	Estimated 15 gallons	Cactus Road south of B440	Soil	Cleaned up the release and stained soil.	Requested owner to check vehicle.
5-11-98	Antifreeze from private vehicle	<1 pint	Parking lot east of PAC 3	Pavement	Cleaned up the release with rags.	Requested owner to check vehicle.
5-11-98	Gasoline from government vehicle ("Cushman cart")	<1 cup	Parking lot east of PAC 1	Pavement	Cleaned up the release with rags.	Requested owner to check vehicle.
5-12-98	Antifreeze from private vehicle	<2 gallons	North of T130J	Pavement	Cleaned up the release with rags and absorbent.	Requested owner to check vehicle.
5-13-98	Antifreeze from government vehicle	½ pint	Parking lot east of B881	Pavement	Cleaned up the release with rags.	Requested owner to check vehicle.
5-18-98	Hydraulic oil from equipment	1 cup	B664 Dock – truck bed	Containment	Rad/chem screened and cleaned up the release.	Bldg. maintenance inspected equipment.
5-28-98	Diesel fuel from overfill of generator tank	<1 gallon	West of B662	Soil	Cleaned up the release and stained soil.	Instructed operators on proper fueling procedures.
JUN '98						
6-3-98	Power steering fluid from private vehicle	< 1 pint	Parking lot south of PAC 2	Pavement	Cleaned up the release with rags.	Requested owner to check vehicle.
6-3-98	Water from portable swamp cooler	< 10 gallons	B779, Room 221	Containment	Rad screened and cleaned up the release.	Install bigger collection container and monitor.
6-4-98	Hydraulic oil from subcontractor's truck	<2 gallons	Between Cactus Road and railroad tracks	Soil	Cleaned up the release and stained soil.	Requested owner to check and repair vehicle.

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DATE	Substance	Amount	Location	Media Released to	Action Taken	Preventative Action/Plan
			southwest of B440			
6-5-98	Cutting oil from subcontractor's pipe threading machine	1 gallon	Outside southeast corner of B770	Soil	Rad/chem screened. Cleaned up the release and stained soil.	Requested owner to inspect and repair equipment.
*6-9-98	Mixed waste acid from tank D843	1-2 gallons	Bermed pavement southeast of B374 Dock 8	Pavement	Rad/chem screened and cleaned up the release. Reported to CDPHE per RCRA Permit.	Inspected waste tank system and similar tanks on site. Evaluated all waste systems and alarm procedures.
6-9-98	Hydraulic oil from dock lever	<1 gallon	B371 Dock 18T	Pavement	Rad screened and cleaned up the release with rags.	Inspected and repaired the equipment.
6-11-98	Oil from generator	1 gallon	PU&D Yard (north)	Soil	Rad screened. Cleaned up the release and stained soil.	Inspect the equipment to ensure all oil has been drained.
6-26-98	Motor oil from press machine (nonrad)	<2 quarts	B881 South Dock	Concrete	Rad screened and cleaned up the release with rags.	Inspect and repair press machine.
6-29-98	Antifreeze (ethylene glycol) from govt. forklift	< ½ gallon	B061	Pavement	Cleaned up the release with rags.	Requested garage to check and repair vehicle.
6-29-98	Gasoline from private vehicle	½ cup	T893A	Soil	Cleaned up the release and stained soil.	Requested owner to check and repair vehicle.
Jul '98						
7-2-98	Antifreeze (ethylene glycol) from government vehicle	1 cup	Southwest side of 123 Pad	Pavement	Cleaned up the release with rags.	Requested garage to check and repair vehicle.
7-3-98	Plutonium nitrate solution	3 tablespoons	B771	Containment	Rad/chem screen and cleaned up the release.	Checked line and repaired valve.
7-9-98	Water from broken lawn sprinkler	2 gallons	Southwest side of B130	Soil	Closed valve and allowed the water to soak into the lawn.	Repaired by maintenance.
7-9-98	Water standing in shallow ditch area after rain	5-10 gallons	Buffer Zone, by Wind Site north of old farm	Soil	Checked by surface water representative and no contamination. Naturally occurring microbes in the soil produced "oil like" sheen. Water allowed to soak into the ground.	Periodic monitoring.
7-10-98	Oil, rad from containers/drum	1 quart	Trench 1, east side of Site	Containment	Rad screened. Cleaned up with rags and repacked the container.	Cautioned the workers to carefully handle the containers.

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7-14-98	Water from evaporation cooler	1 gallon	B865, Mezzanine	Containment	Rad/chem screened and cleaned up the release.	Install bigger collection container and monitor.
7-16-98	Antifreeze (ethylene glycol) from government vehicle	< 1 pint	B567	Pavement	Cleaned up the release with rags.	Requested garage to check and repair vehicle.
7-16-98	Phosphoric acid	< 1 gallon	B551, paint vault flammable cabinet	Containment	Chem screened. Cleaned up the release.	Checked the other containers in the cabinet for leaks or cracks. Reviewed safe handling procedures.
7-21-98	Used motor oil, from container in private vehicle	¾ gallon	Parking lot B121	Soil	Cleaned up the release and stained soil. Repacked the oil remaining in the container.	Request owner to secure all liquids in secondary containers and not to bring it on Site.
7-23-98	Water from cooling system	5 gallons	B865, Room 6	Containment	Rad/chem screened. Cleaned up the release.	Maintenance inspected the cooling system and completed repairs.
7-25-98	Oil from compressor	5 gallons	B243 Nitrogen Bldg.	Containment	Rad/chem screened. Cleaned up the release.	Maintenance inspected the compressor and completed repairs.
7-29-98	Oil (from container) (in rad flammable cabinet)	½ cup	B566, Laundry Bldg., Room Cage 125	Containment	Rad/chem screened. Cleaned up the release.	Inspected the other containers in the Cage to identify any other leaks or cracks in the container.
7-30-98	Shower decon water (in rad area)	7 gallons	B779, Room 224	Containment	Rad/chem screened. Cleaned up the release. Cleared drain.	Monitor the drain.
AUG'98						
8-3-98	Diesel fuel from portable emergency generator	2 gallons	Southeast of B662	Soil	Cleaned up the release and stained soil.	Request operator to review proper filling procedures.
8-11-98	Antifreeze (ethylene glycol) from forklift	1 cup	Inside Trench 1 tent	Containment	Rad screened and cleaned up the release with rags.	Requested garage to check and repair forklift.
8-11-98	Process waste (rad mixed residue) from waste tank #1007 (EPA Code D002/D008)	3-4 fl. oz.	B771, Room 146, Glovebox MT-1	Containment	Rad/chem screened. Isolated valve/tank and cleaned up the release.	Daily inspection of valve and waste tank system.
8-13-98	Hydraulic oil from forklift	< 1 pint	B374, Room 4101	Floor	Cleaned up the release with rags.	Requested garage to check and repair vehicle.

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DATE	Substance	Amount	Location	Media Released to	Action Taken	Preventative Action/Plan
8-14-98	Process waste (rad) from valve on "operationally empty" Tank 934	<2 fl. oz.	B771, Room 149	Floor	Rad/chem screened. Isolated the tank/valve and cleaned up the release.	Tank piping system inspection was completed.
8-14-98	Water (nonrad) from condense pipe	60 – 100 gallons	B771, Room 149A	Floor / sanitary drain	Rad/chem screened. Rerouted the drainage to isolate the release water until sampling results were evaluated. Cleaned up the release.	Permanently cap the sanitary drain to prevent any release to the sanitary system.
8-14-98	Process waste (rad) from valve 19-16 on Tank 1014	<1 fl. oz.	B771, Room 146	Floor	Rad/chem screened. Isolated tank valve and cleaned up the release.	Adjusted valve and inspect daily.
8-15-98	Potassium hydroxide (KOH) from "operationally empty" drained product tank	1.5 liters	North of B374	Containment	Rad/chem screened. Isolated valve and tank. Cleaned up the release.	The tank system was inspected and repaired.
8-17-98	"Incidental waters" – groundwater in pit being pumped into tanker truck	100 gallons	West side of B886	Soil	Rad screened. Water was sampled and the results indicated nonhazardous and allowed to be released to the soil/groundwater.	Revised pumping procedures (Operations Order #00889-15). Lesson's learned safety briefings were presented.
8-19-98	Asbestos – small piece from water saturated pipe insulation	< 1 lb.	B776, Roof	Roof	Rad screened. Cleaned up the release.	Pipe insulation repaired.
8-19-98	Oil from vacuum line	1 drop	B771, Room 146	Floor	Rad/chem screened. Isolated line. Cleaned up the release.	Inspected and repaired valve.
8-19-98	Ethylene glycol (antifreeze) from emergency generator radiator	½ gallon	North side of B776	Pavement	Cleaned up the release with rags.	Inspected and repaired the generator.
8-20-98	"Incidental water" – groundwater (non hazardous) splashed from tanker truck	Estimated 10 gallons	Street from B371 to PAC #1	Pavement	Water sample results showed the release water to be nonhazardous and within levels that can be released to the soil/groundwater.	Requested truck driver to review procedures and follow all vehicle checks prior to moving the truck.
8-24-98	Hydraulic oil from	3 gallons	Parking lot	Pavement	Oil mixed into the pavement being poured.	Request contractor to inspect all

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	paving equipment		southeast corner at Central & 7 th Streets		Prior to the oil release, a sealer was sprayed over the soil.	equipment prior to bringing on Site.
8-26-98	Gasoline from government vehicle	2 cups	T893B north parking lot	Pavement	Cleaned up the release with rags.	Requested garage to check and repair vehicle.
8-31-98	Water (condensate) from hot water line in heat exchanger	1 pint	B771, Room 114	Floor/Containment	Rad/chem screened. Cleaned up the release.	Monitor the area.
SEP-98						
9-2-98	Pu Nitrate solution (rad) from flange during disassembly of system.	12 fl. oz.	B886, Room 101	Containment	Rad/chem screened and cleaned up release.	Daily inspections of area.
9-3-98	Antifreeze (ethylene glycol) from forklift	0.5 gallon	B130 Receiving dock	Pavement	Cleaned up the release with rags.	Requested garage to check equipment.
9-8-98	Antifreeze (ethylene glycol) from govt. vehicle	0.5 pint	West of B371	Pavement	Cleaned up the release with rags.	Requested garage to check vehicle.
9-15-98	Antifreeze (ethylene glycol) from private vehicle	1 gallon	Parking lot north of B124A	Pavement	Cleaned up the release with rags.	Requested owner to check vehicle.

* Reported to Colorado Department of Public Health and Environment.